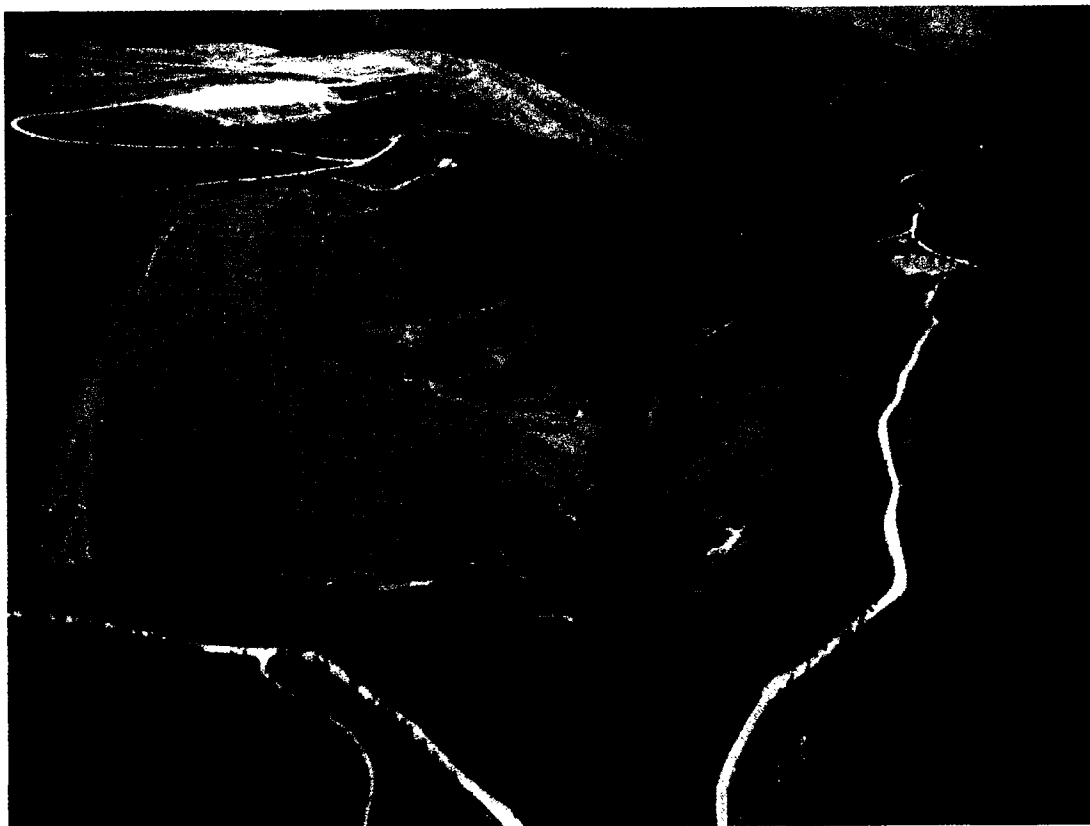


DRAFT
PROBLEM FORMULATION FOR ECOLOGICAL RISK ASSESSMENT AT
OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE



February 22, 2008

Prepared by:
US Environmental Protection Agency
Region 8
Denver, CO



ADMINISTRATIVE RECORD

With Technical Assistance from:
Syracuse Research Corporation
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LIST OF ACRONYMS

BTAG	Biological Technical Assistance Group
cc	Cubic Centimeter
cfs	cubic feet per second
COC	Chain of Custody
COPC	Chemicals of Potential Concern
CSM	Conceptual Site Model
DO	Dissolved Oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EDS	Energy Dispersive Spectroscopy
FS	Feasibility Study
GI	Gastrointestinal
GRAV	Gravimetric
ha	hectare
HQ	Hazard Quotient
HQmax	Maximum Hazard Quotient Value
IMEE	In-Situ Measures of Exposure and Effects
ISO	International Organization for Standardization
KDC	Kootenai Development Corporation
LA	Libby Amphibole
MDEQ	Montana Department of Environmental Quality
MFL	Million Fibers per Liter
MMU	Minimum Map Unit
MNHP	Montana National Heritage Program
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDO	Population and Community Demographic Observations
PCM	Phase Contrast Microscopy
PEC	Probably Effect Concentration
PLM	Polarized Light Microscopy
PLM-VE	Polarized Light Microscopy Visual Area Estimation Method
PLM-PC	Polarized Light Microscopy Point Count Method
RBP	Rapid Bioassessment Protocol
RI	Remedial Investigation
SAED	Selective Area Electron Diffraction
SAP	Sampling and Analysis Plan
SEM	Scanning Electron Microscopy
SOP	Standard Operating Procedure
SSTT	Site-Specific Toxicity Tests

1.0 INTRODUCTION

This document is an initial Problem Formulation for the ecological risk assessment (ERA) that will be performed for Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site located near Libby, Montana.

Problem formulation is a systematic planning step that identifies the major concerns and issues to be considered in an ERA, and describes the basic approaches that will be used to characterize ecological risks that may exist (USEPA 1997). As discussed in USEPA (1997), problem formulation is generally an iterative process, undergoing refinement as new information and findings become available (Figure 1-1).

The first step in the ecological problem formulation is the review of available information on the nature of the site and the ecological setting, the nature of the contaminants that may be present in environmental media, and the types of ecological organisms that may come into contact with contaminated media. This information is summarized in Section 2 of this document.

The next step is to utilize the information that is available to develop one or more Conceptual Site Models (CSMs), which summarize the understanding of contaminant sources, fate and transport pathways, and exposure pathways that are potentially relevant for each group of ecological receptors. This information is presented in Section 3 of this document. As noted above, the CSM may be refined in an iterative process as new information becomes available.

The next step in problem formulation is to identify the risk management objectives at the site, and to select approaches for assessing whether those objectives are achieved or not. Section 4 of this document presents the risk management goals for the site, and reviews the general strategies that are available to assess risks to ecological receptors.

Section 5 presents a description of the specific strategy that will be followed to evaluate risks to ecological receptors from non-asbestos contaminants that may be present at the site. Section 6 presents a detailed evaluation of the specific strategy that will be followed for evaluating ecological risks from asbestos.

2.0 SITE CHARACTERIZATION

2.1 Site Location

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. The mine location and preliminary study area boundary of Operable Unit (OU) 3 are shown in Figure 2-1. EPA established this preliminary study area boundary for the purpose of planning and developing the initial scope of the RI/FS for OU3. This preliminary boundary may be revised as results from the RI clarify the extent of environmental contamination associated with releases that may have occurred from the mine site.

2.2 Physical Setting

Land Use

The terrain in OU3 is mainly mountainous with dense forests and steep slopes. Current land ownership in the area is shown in Figure 2-2. Kootenai Development Corporation (KDC), a subsidiary of W.R Grace & Co., owns the mine area and the immediately adjacent portion of the off-mine area. The majority of the surrounding land is owned by the United States government and is managed by the Forest Service, with some land parcels owned by the State of Montana and some owned by Plum Creek Timberlands LP for commercial logging.

Climate

Northern Montana has a climate characterized by relatively hot summers, cold winters, and low precipitation. Table 2-1 presents climate data collected at the Libby NE Ranger Station, which is located just west of the town of Libby near the Kootenai River. Average summer high temperatures (°F) are in the upper 80s, and low temperatures are in the 40s, while winter highs are in the 30s and lows are in the teens. The western mountain ranges cause Pacific storms to drop much of their moisture before they reach the area, resulting in relatively low precipitation, averaging about 18 inches per year. The most abundant rainfall occurs in late spring/early summer. In the winter months, snowfall averages 54 inches each year and snow cover typically remains on the ground from November through March. Data collected from a weather station at the mine site indicate that winds are predominantly to the northeast (Figure 2-3).

Surface Water Features

The mine is located within the Rainy Creek watershed, which includes Rainy Creek, Carney Creek and Fleetwood Creek (Figure 2-4). The area drained is approximately 17.8 square miles.

Rainy Creek

Rainy Creek originates between Blue Mountain and the north fork of Jackson Creek at an elevation of about 5,000 feet, and falls to an elevation of 2,080 feet at the confluence with the Kootenai River (Zinner 1982). The average gradient for Rainy Creek is about 12% (Parker and Hudson 1992), and the banks are well vegetated (MWH 2008).

Fleetwood and Carney Creeks

Fleetwood Creek and Carney Creek are tributaries to Rainy Creek (Figure 2-4). The average stream gradient for Fleetwood Creek is about 11% (Parker and Hudson, 1992). Under current site conditions, Fleetwood Creek flows through a portion of mine waste before flowing into a large tailings impoundment which was constructed within the former Rainy Creek channel (see below). A ponded area was identified along Fleetwood Creek during reconnaissance surveys by EPA in 2007. This area is devoid of vegetation (Figure 2-9).

Carney Creek flows along and through mine waste on the south side of the mined area before joining Rainy Creek. During an aerial survey in 2008, a small pond was discovered on Carney Creek (Figure 2-9). This pond was formed when waste piles were deposited in the drainage and blocked and altered the flow of the creek. The pond is vegetated on one side. Several small springs are reported along Carney Creek (Zinner, 1982) and were identified during reconnaissance surveys by EPA in 2007 (Figure 2-9).

Tailings Impoundment

In 1972, W.R. Grace & Co. constructed a tailings impoundment that received the discharge of process waters that had previously been directly discharged to Rainy Creek. The impoundment was built to provide for settlement of the fine tails produce by the new (wet) process and to recover water for reuse. The height of the dam which forms the impoundment is about 135 feet measured from the downstream toe. The impoundment occupies 70 acres (Figure 2-5).

The impoundment receives input from both upper Rainy Creek and Fleetwood Creek (Figure 2-4). The impoundment drains through a toe drain directly into Rainy Creek, and may also discharge to Rainy Creek via an overflow channel during high flow events (Parker and Hudson, 1992).

Mill Pond

A pond in the Rainy Creek channel downstream of the tailings impoundment was constructed to provide a water supply for mining operations. The pond discharges to Rainy Creek where it mixes with flow from Carney Creek and flows downstream to the Kootenai River. This reach has some seasonal gain in flow, most likely due to groundwater input (USEPA, 2007).

Kootenai River

The Kootenai River flows from east to west along the south side of the site. Flows in the Kootenai River are controlled by the Libby Dam, which was constructed in the late-1960s and early-1970s as part of the Columbia River development for flood control, power generation, and recreation. Daily water outflow plans¹ for October 2006 through August 2007 show lowest discharge flows in March and October at approximately 4,000 cubic feet per second (cfs) and maximum discharge flows in late May/early June at 26,600 cfs.

State Water Use Designations

Table 2-2 presents designated uses for Rainy Creek and the Kootenai River near and downstream of the mine area, as classified by the State of Montana Administrative Rules Chapter 30 Water Quality Subchapter 5 (§17.30.609) for the Kootenai River drainage. The State of Montana has established numeric standards for the protection of aquatic life and human health associated with the designated uses. The numeric standards are set forth in the Montana Department of Environmental Quality Circular DEQ-7 – Montana Numeric Water Quality Standards.

Occurrence and Nature of Asbestos at the Mine

The mine is located in a region of the Precambrian Belt Series of northwestern Montana that has been intruded by an alkaline-ultramafic body. The Rainy Creek Igneous Complex comprises the upper portion of this intrusion. Hydrothermal alteration of the biotite pyroxenite intrusion produced the large, high-quality vermiculite deposit. The vermiculite content of the ore varies considerably within the deposit, ranging from 30 to 84%.

Fibrous and asbestiform amphiboles are present in association with the vermiculite ore (see Section 6.1 for more information on asbestos mineralogy). A significant portion of the fibrous amphiboles are located along cross-cutting veins and dikes and in the altered pyroxenite wall rock adjacent to them. The alteration zones, dikes, and veins that range in width from a few millimeters to meters in thickness are found throughout the deposit. Amphibole content in the alteration zones of the deposit is estimated to range between 50-75%. The U.S. Geological Survey (USGS) performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from the exposed asbestos veins to identify the type of amphibole asbestos present in the mine (Meeker et al. 2003). The results indicated that a variety of amphiboles exist at this site, including winchite, richterite, tremolite, actinolite, and magnesioriebeckite. The EPA refers to this mixture of amphibole asbestos minerals as Libby Amphibole Asbestos(LA).

¹ Available from http://www.nwd-wc.usace.army.mil/ftp/pub/project_data/yearly/lib_wy_qr.txt

Historic Mine Operations and Current Features

Figure 2-5 shows the current mine features and location of historical mining operations. The mine was operated from 1923 until 1990 and was open pit except for a short period in the early period of operations. The mine area is heavily disturbed by past mining activity and some areas remain largely devoid of vegetation. There are a number of areas where mine wastes have been disposed (Figure 2-5), including waste rock dumps (mainly on the south side of the mine), coarse tailings (mainly to the north of the mine), and fine tailings (placed in the tailings impoundment on the west side of the site).

The basics of ore processing did not change over the period of operation, although unit operations were changed as ore quality decreased and technology improved, and in response to concerns over dust generation (Zucker, 2006). In general, rock was removed to allow access to the vermiculite or separated from the vermiculite in the mine pits and dumped over the edge to form waste rock piles (see Figure 2-5). After 1971, ore was processed to separate out vermiculite product by crushing, screening or water floatation, with those operations generally occurring in the mill area (Figure 2-5).

A storage and loading facility along the river at the mouth of Rainy Creek was built in 1949. It included a 600-foot conveyor belt for carrying material across the Kootenai River, and a loading facility along the Great Northern Railroad tracks on the south side of the river.

A new concentrating plant began operations in 1954 in the general milling area (Figure 2-5). This plant was designed to separate the vermiculite from ore that contained less than 35% vermiculite. Continued refinements led to implementation of a wet process, in which a froth flotation process was coupled with shaking tables to separate waste rock from the vermiculite. The dry mill continued to operate. After passing through a two-inch grizzly, ore went to one of five storage bins at the mill. Ore was blended and sent to the primary screens at the mill where water was added. Oversize material was concentrated in jigs and dried in rotary driers. The material was then crushed using hammer mills and roll crushers before being screened, with finer material further separated using spiral concentrators. Material was then dewatered and dried before being screened for product. The process generated two types of waste material; coarse tailings which were disposed in a pile to the north (Figure 2-5) and fine tailings which appear to have been discharged to Rainy Creek until a tailings impoundment was constructed in 1971.

W.R. Grace & Co.-Conn. (then known as W.R. Grace & Co.) took over mining in 1963. In 1971, they undertook a major expansion to increase capacity and improve the beneficiation process. It was at this time that the tailings impoundment was built to provide for settlement of the fine tailings produced by the new process and to recover water for reuse (Schafer, 1992). The dam was designed and constructed in stages, with a 50 foot high starter dam constructed in 1971, immediately downstream of an older, existing dam. Additional construction phases in 1975, 1977, and 1980 raised the top of the dam to a total height of 135 feet measured from the downstream toe.

Remedium reviewed historic information on mining operations at the site and reported that in a typical year about 5 million tons of rock was mined to generate 220,000 tons of vermiculite product. Primary waste materials were waste rock (3.5 million tons per year) and tailings (1.1 million tons per year), with lesser amounts of oversize rock and screening plant concentrate wastes. As higher quality ores were depleted and lesser quality ores were mined, various reagents were used to facilitate the separation. Reported reagents include #2 Diesel Fuel (typically between 1.2 and 5.4 million pounds per year), Armeen T (Tallow Alkyl Amine; 100,000 to 500,000 pounds per year), fluorosilicic acid (50,000 to 240,000 pounds per year) and lesser quantities of flocculants, defoamers, frothers and other reagents.

2.3 Ecological Setting

2.3.1 Terrestrial Habitats and Plant Species

Most of OU3 is forested, with only 4% of the land being classified as non-forest or water (USDAFSR1, 2008; Figure 2-6). Data for the National Forest indicate Douglas-fir forest type is the most common, covering nearly 35 percent of the National Forest land area. Next in abundance are the lodgepole pine forest type and spruce-fir forest type at 17 percent each, and the western larch forest type at 11 percent. Other species reported in the area are the Black Cottonwood (*Populus trichocarpa*), Quaking Aspen (*Populus tremuloides*), Western Paper Birch (*Betula papyrifera* var. *occidentalis*) and Pacific Yew (*Taxus brevifolia*) (USDAFSR1, 2008).

Specific vegetative surveys of the Libby OU3 mine site are not available. Therefore, an initial vegetative cover map was created using existing information from the analyses of remote sensing data. In 1998, the Wildlife Spatial Analysis Lab at the University of Montana in Missoula created the *Montana Land Cover Atlas* as part of the Montana Gap Analysis Project (Fisher et al., 1998). Data from this project classifies 50 land cover types. The group developed the classification based on the hierarchical design of Anderson et al. (1976) in the same manner as was accomplished in Wyoming (Merrill et al. 1996). Land cover types were targeted and defined according to known occurrences in the state and from classifications used for GAP projects in both Idaho (Caicco et al. 1995) and Wyoming (Merrill et al., 1996). The final list of 50 land cover types is shown in Table 2-3. Vegetative cover on and in the vicinity of the Libby OU3 Site is provided as Figure 2-7. The map is generated from Landsat Thematic Mapper (TM) data covering Montana. Upland cover types were mapped to 2 hectare (ha) minimum map unit (MMU). Based on this mapping, the vegetative cover around the mine site is predominantly Douglas-fir, lodgepole pine and mixed mesic forest.

2.3.2 Aquatic Species

Rainy Creek Watershed

Within the Rainy Creek watershed there are streams and ponds that provide habitat for aquatic species including plants, invertebrates, amphibians, and fish. The U.S Forest Service has compiled data on the species and genetic type of fish in Rainy Creek, but EPA has not yet been able to access these data.

The Montana National Heritage Program (MNHP) lists 25 species of fish that are expected to occur in the area. Of these 12 are considered to be possible inhabitants of waters in the Rainy Creek watershed. These species include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), Columbia River redband trout (*Oncorhynchus mykiss gairdneri*), fathead minnow (*Pimephales promelas*), largescale Sucker (*Catostomus macrocheilus*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mottled sculpin (*Cottus bairdi*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), torrent sculpin (*Cottus rhotheus*), and westslope cutthroat trout (*Oncorhynchus clarkii lewisi*). The Montana Fish Wildlife and Parks reports that the westslope cutthroat trout is a year round resident in both upstream Rainy Creek and upstream Carney Creek.

It is possible that some of the ponds and impoundments in the Rainy Creek watershed might support some other species of fish that are not expected to occur in high grade mountain streams, but no data have been located on this issue.

Kootenai River

EPA's Environmental Monitoring and Assessment Program (EMAP) has collected aquatic community data at a station on the Kootenai River about one mile downstream of the confluence with Rainy Creek. This location was sampled in August 2002. Forty-four species of aquatic invertebrates have been observed, including oligochaetes, insects (diptera, ephemeroptera, trichoptera and hemiptera), colenterates (hydra), mollusks, and nematodes (see Table 2-4). Eleven species of fish were observed (Table 2-5). Mountain whitefish were most common, along with several species of salmonids (rainbow trout, sockeye salmon, cutthroat trout, bull trout) and several species forage fish (dace, shiner, sculpin)..

2.3.3 Wildlife Species on or Near the Libby OU3 Site

The Montana Natural Heritage Program is a source for information on the status and distribution of native animals and plants in Montana. An assessment of which wildlife species are expected to occur at the Libby OU3 site was performed based on the Montana Natural Heritage Program Animal Tracker (<http://nhp.nris.mt.gov/Tracker/>). First, all species known to occur within Lincoln County, Montana, were identified. Next, the Montana Natural Heritage Program and Montana Fish, Wildlife and Parks Animal Field Guide (<http://fieldguide.mt.gov/>) was consulted

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to identify if a particular species was observed near the Libby OU3 Site. Species not identified within the vicinity of OU3, and those not expected to occur at OU3 based on a consideration of available habitat, were removed. The species that remained are listed in Attachment A, along with information on general habitat requirements, habitat type for foraging and nesting, feeding guild, typical food, migration and hibernation, longevity, home range and size. The oldest recorded sighting and latest (year), and the number of individuals identified was also recorded.

The species identified as residing within Libby OU3 include 29 invertebrates (26 terrestrial and 3 aquatic), 24 fish, 7 amphibians, 7 reptiles, 175 birds, and 48 mammals.

2.3.4 Federal and State Species of Special Concern

There are six federally listed protected species that have been reported to occur in or about the vicinity of the Libby OU3 Site, including 2 fish, 1 bird, and 3 mammals. These are listed in Table 2-6. Species of concern to the State of Montana that have been observed to occur in the vicinity of Libby OU3 Site are listed in Table 2-7. This includes 2 amphibians, 7 birds, 4 mammals, 3 fish, and 7 invertebrates. However, not all of these species are equally likely to occur within the OU. Based on an evaluation of frequency of observation, the following listed species are considered to be the most likely to be present in the OU:

- Coeur d'Alene Salamander (*Plethodon idahoensis*)
- Boreal Toad, Green (also known as Western Toad) (*Bufo boreas*)
- Flammulated Owl (*Otus flammeolus*)
- Northern Goshawk (*Accipiter gentilis*)
- Bull Trout (*Salvelinus confluentus*)
- Torrent Sculpin (*Cottus rhotheus*)
- Westernslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*)
- White Sturgeon (*Acipenser transmontanus*) (Kootenai River Pop.)

2.4 Summary of Data Available from Phase I

In 2007, EPA began performance of a Remedial Investigation (RI) for Libby OU3. The RI began by collection of an initial round (referred to as Phase I) of environmental samples of a variety of media (surface water, sediment, on-site and off-site soils, tree bark) in the fall of 2007. These samples were analyzed for LA and/or a range of non-asbestos analytes. The raw data from the Phase I investigation are presented in Attachment B and are summarized below.

2.4.1 Asbestos

Surface Water and Sediments

Surface water and sediment samples were collected during the Phase I investigation at a total of 24 locations, as shown in Figure 2-8. Figure 2-9 provides color photos of a number of the sampling stations.

Surface water were analyzed for LA by Transmission Electron Microscopy (TEM) using Modified EPA Method 100.2 (USEPA, 1994) in accord with the modified counting procedures described in Libby Laboratory Modification LB-000020 (USEPA, 2007). Table 2-8 summarizes the results of the analysis of surface water for asbestos (LA). Results are expressed in terms of million fibers per liter (MFL). The results are also mapped in Figure 2-10 to show the spatial pattern of results. The highest levels were observed in samples located in ponds or impoundments, including the tailings impoundment, the mill pond, and the pond on Fleetwood creek, as well as from several seeps along the south side of the mined area. Levels in lower Rainy Creek (below the mill pond) are relatively lower.

Sediment samples were prepared for LA analysis by sieving into coarse ($> \frac{1}{4}$ inch) and fine fractions. The fine fraction was ground to reduce particles to a diameter of 250 μm or less and separated into 4 aliquots. The coarse fraction soil aliquot (if any) was examined using stereomicroscopy, and any particles of asbestos (confirmed by PLM) were removed and weighed. The fine ground fraction was analyzed by PLM visual area estimation method (PLM-VE) using Libby-specific reference materials in accordance with SRC-LIBBY-03 Revision 2. Results from the PLM-VE method are semi-quantitative, with an estimated detection limit for LA of about 0.2% or slightly less.

The results of the analyses of the fine and coarse fractions of the sediments are shown in Table 2-9. The results are also mapped in Figure 2-11 to show the spatial pattern of results. Results for LA in sediment are expressed as mass percent (grams of asbestos per 100 grams of soil) if the concentration is 1% or higher. If the estimated concentration is $<1\%$, the results are expressed semi-quantitatively, according to the following scheme:

PLM-VE Result	Range of Mass Percent
A (ND)	None detected (likely $< 0.05\%$)
B1 (Trace)	LA detected, $> 0\%$ but $< 0.2\%$
B2 ($<1\%$)	LA detected, $>0.2\%$ but $< 1\%$

Nearly all (22 out of 24) of the sediment samples collected contain LA. Of these, one is classified as Bin B1 ($<0.2\%$), 12 are classified as Bin B2 (about 0.2 to 1%), and 9 were estimated to contain levels from 2-7%. These results indicate that asbestos in sediment is widespread throughout the surface water features draining the site, and that levels are substantial in many locations.

Mine Wastes and Soils

Figure 2-12 shows the locations of the mine waste and/or soil samples. The Phase I samples focused on each of the principal mine waste materials identified to date including mine waste rock, impounded tailings, and coarse tailings as well soils in the former mill area and soils in the former mill area; and materials used for construction of unpaved sections of Rainy Creek Road.

Soil samples collected for asbestos analysis were prepared and analyzed in the same manner as previously described for sediments. Table 2-10 summarizes the results of the analysis of the fine fraction of mine waste and soil samples for LA. All but one soil sample (33 of 34) contained LA. Of these, two are classified as Bin B1 ($<0.2\%$), 26 are classified as Bin B2 (0.2% to 1%), and 5 are estimated to contain levels from 2% - 8% .

Tree Bark, Forest Soil and Duff

During Phase 1, samples of tree bark, forest soil and organic debris (duff) were collected at a number of stations located on transects that radiate away from the mine, with special emphasis on the predominant downwind direction (northeast) (Figure 2-13). All bark samples were collected from the side of the tree facing toward the mine site, from a height of about 4-5 feet above ground. Forest soil and duff samples were collected from approximately equally spaced locations around the perimeter of a circle with a radius of about 5 feet, centered on the tree where the bark sample was collected. The grab samples were combined into one composite and analyzed for asbestos as previously described for mine waste and soils.

The soil samples were analyzed for LA by PLM-VE. The results are provided in Table 2-11 and are plotted in Figure 2-14. As seen, LA was detectable in a number of soil samples located relatively close to the mined area, but was not detectable at a distance more than about 1.5 miles from the mined area. The transport mechanism leading to the observed soil contamination is not known, but it is considered likely that both air transport and water-based erosion may have contributed.

The results of the tree bark and duff samples are not yet available.

Ambient Air

The purpose of the Phase I ambient air sampling was to obtain data on the level of releases occurring from the mine area to adjacent downwind areas under current site conditions. The basic sampling design for ambient air consists of two concentric rings of stationary air monitors placed around the mine. The first ring is close to the boundary of the disturbed area, and the second ring is close to the perimeter of the property owned by KDC. Figure 2-15 shows the locations for the ambient air monitors. Each sample was collected over a period of 5 days, with samples being collected once per week for a period of four weeks. All air samples were analyzed for asbestos by TEM in accord with the ISO 10312 method (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications, including the most recent versions of modifications as specified in the SAP (USEPA, 2007).

The results of analyses of asbestos in the ambient air samples are provided as Table 2-12. Asbestos was not detected in any of the field samples. These results should be interpreted

cautiously because ambient air samples were collected over a time interval when rain was occurring frequently, which may have reduced the potential for airborne releases to ambient air.

2.4.2 Non-Asbestos Contaminants

Surface Water

Surface water samples were collected during the Phase I investigation at a total of 24 locations, as shown in Figure 2-8. The surface water samples collected during Phase I were analyzed for metals and metalloids, petroleum hydrocarbons, anions, and other water quality parameters. In addition, several selected surface water samples were analyzed for a broad suite of other chemicals. Table 2-13 lists the analytical methods and analyses for the Phase I samples. Table 2-14 shows the analyses that were performed for each sampling location. In addition to laboratory analyses, surface water samples were analyzed in the field for surface water quality parameters. Surface water flow was also measured at each sampling location.

The results of the analyses of Phase I surface water samples for non-asbestos analytes are provided in Table 2-15. The analytes listed in the table are those that were detected in at least one surface water sample. The results of water quality parameters measured in the field are provided in Table 2-16. Flow measurements are provided in Table 2-17. Nine metals were detected as well as benzene, aliphatic hydrocarbons, total petroleum hydrocarbon (TPH), total extractable hydrocarbons (TEH), nitrate, nitrite, chloride, fluoride, sulfate, and phosphate. Volatile organic chemicals (VOCs), semi-volatile organic chemicals (SVOCs), polychlorinated biphenyls (PCBs), pesticides and polycyclic aromatic hydrocarbons (PAHs) were not detected in any of the surface water samples.

Sediment

Sediment water samples were collected during the Phase I investigation at a total of 24 locations, as shown in Figure 2-8. All sediment samples were analyzed for asbestos, metals and metalloids, petroleum hydrocarbons, and several sediment quality parameters. In addition, several selected sediment samples were analyzed for a broad suite of other chemicals. Table 2-18 lists the analytical methods that were employed, and Table 2-19 shows the analyses that were performed at each station.

The results of the analyses of the Phase I sediment samples are provided in Table 2-20. The analytes listed in the table are those that were detected in at least one sediment sample. The full results of the analyses are included in Attachment B. Fifteen metals were detected as well as pyrene, methyl acetate, aromatic and aliphatic hydrocarbons, TEH, and TPH. Figure 2-16 displays the results for chromium, and Figure 2-17 displays the results for TPH. Other analytes, including PCBs, SVOCs and pesticides, and were not detected in any of the sediment samples.

On-Site Soil and Mine Waste

Figure 2-12 shows the locations of the on-site mine waste and/or soil samples collected during Phase I. These samples focused on each of the principal mine waste materials identified to date including mine waste rock, impounded tailings, and coarse tailings as well soils in the former mill area and soils in the former mill area; and materials used for construction of unpaved sections of Rainy Creek Road. These samples are divided into six categories:

Road	MS-1 to MS-2
Tailings Impoundment	MS-4 and M-5
Coarse Tailings	MS-6 to MS-9
Cover Material	MS-10 to MS-13; MS-21 to MS-24
Waste Rock	MS-14 to MS-20; MS-26 to MS-30; MS-32
Outcrop	MS-25; MS-31; MS-33-38

All mine waste and soil samples were analyzed for asbestos, metals and metalloids, petroleum hydrocarbons, as well as pH, moisture content and organic carbon content. This was with the exception of outcrop samples which were not analyzed for petroleum hydrocarbons. In addition, several selected mine waste and soil samples were analyzed for a broad suite of other chemicals. Table 2-21 lists the analytical methods that were used, and Table 2-22 shows the analyses that were performed at each sampling location.

The results of the analyses of the Phase I mine waste and soil samples are provided in Table 2-23. The results listed in the table are those for analytes that were detected in at least one mine waste or soil sample. The full results of the analyses from the Phase 1 sampling program are included in Attachment B. Fifteen metals, eight PAHs, one pesticide (pentachlorophenol), one VOC (methylacetate), aromatic and aliphatic hydrocarbons, TEH, toluene and TPH were detected. PCBs and SVOCs were not detected in any of the mine waste and soil samples.

3.0 CONCEPTUAL SITE MODELS

After review of available information on the site, the ecological setting and the nature of contaminants that may be present, the next step in problem formulation for an ecological risk assessment is the development of a Conceptual Site Model (CSM). The CSM is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors may be exposed to site-related contaminants. When information is sufficient, the CSM may also indicate which of the exposure scenarios for each receptor are likely to be the most significant, and which (if any) are likely to be sufficiently minor that detailed evaluation is not needed.

Figure 3-1 presents the CSM for exposure of each general ecological receptor group (fish, benthic invertebrates, terrestrial plants, soil invertebrates, birds and mammals and amphibians) to non-asbestos mining-related contaminants, and Figure 3-2 presents the CSM for exposure to asbestos. The two CSMs are similar to each other, except that the exposure pathways of chief concern may differ due to the differing properties of asbestos and non-asbestos contaminants.

As seen, each receptor group may be exposed by several different pathways. However, not all pathways are equally likely to be important. In each CSM, pathways are divided into four main categories:

- A solid black circle (●) represents pathways that are believed to be complete, and which may provide an important contribution to the total risk to a receptor group.
- An open circle (○) represents an exposure pathway that is believed to be complete, but which is unlikely to be a major contributor to the total risk to a receptor group, at least in comparison to one or more other pathways that are evaluated.
- A question mark (?) represents an exposure pathway that is believed to be complete, but data available are not adequate to decide if the pathway is or is not a major contributor to the total risk to the receptor group.
- An open box represents an exposure pathway that is believed to be incomplete (now and in the future). Thus, this pathway is not assessed.

The following sections provide a more detailed discussion of the main elements of these CSMs.

3.1 Potential Sources of Contamination

The main sources of asbestos contamination at this site are the mine wastes generated by historic vermiculite mining and milling activities. This includes piles of waste rock and waste ore at on-site locations, as well as the coarse tailings pile and the fine tailings impoundment. These wastes may also be sources of metals and other inorganic constituents of the ore. In addition, some

chemicals used at the mine site in the processing of vermiculite ore might also be present in onsite wastes, including diesel fuel, alkyl amines, fluorosilicic acid, and various other flocculants, defoamers, frothers and other reagents.

3.2 Migration Pathways in the Environment

From the sources, contaminants may be released and transported via airborne emissions, surface water transport or food chain transport.

Airborne Transport. Contaminants may become suspended in air and transported from sources via release mechanisms such as wind, mechanical disturbances and/or erosion. Once airborne, contaminants may move with the air and then settle and become deposited onto surface soils. This pathway is likely to be important for asbestos, but is thought to be of low concern for non-asbestos contaminants.

Surface Transport. Contaminants may be carried in surface water runoff (e.g., from rain or snowmelt) from the mine or other areas where soil is contaminated, and become deposited in soils or sediments at downstream locations. This pathway is equally applicable to both asbestos and non-asbestos contaminants.

Food Chain Transport. Contaminants may be taken up from water, sediment or soil into the tissues of aquatic or terrestrial organisms from water and/or sediment and/or soils and/or prey items into prey items (fish, benthic invertebrate, plants, soil invertebrates, birds, mammals). This is applicable to both asbestos and non-asbestos contaminants.

3.3 Potentially Exposed Ecological Receptors

As discussed in Section 2.3, there are a large number of ecological species that are likely to occur in OU3 and that could be exposed to mine-related contaminants. However, it is generally not feasible or necessary to evaluate risks to each species individually. Rather, it is usually appropriate to group receptors with similar behaviors and exposure patterns, and to evaluate the risks to each group.

For aquatic receptors, organisms are usually evaluated in two groups:

- Fish
- Benthic macroinvertebrates

For terrestrial receptors, organisms are usually grouped into five broad categories:

- Plants
- Soil invertebrates
- Birds

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- Mammals
- Amphibians

Screening assessment usually begins by assessing risks to each group as a unit. In cases where risks appear to be above a level of concern for a large group (e.g., birds, mammals), it may sometimes be useful to divide the groups into smaller sub-groups to allow a more refined assessment. For example, when needed, birds and mammals may be stratified into a number of feeding guilds. Based on the information regarding the types of birds and mammals that are present at this site, the following feeding guilds may be useful if a refined assessment is required for an assessment of wildlife populations at the site.

- *Invertivorous Wildlife* – Invertivorous wildlife consume primarily soil invertebrates and are important in nutrient processing and energy transfer within the terrestrial environment. Insectivorous birds and bats are also important in the control of populations of emerging aquatic insects. These animals also are important food sources for other mammals and birds (carnivores). This group of receptors can be further subdivided according to where and how the organism feeds on invertebrates. Some avian species are *aerial invertivores* feeding on insects in flight. Other avian and mammalian species feed primarily on invertebrates in trees (*arboreal insectivores*).
- *Herbivorous Wildlife* – Herbivorous wildlife consume primarily plant material and are important in nutrient processing and energy transfer within the terrestrial environment. Small herbivorous mammals are important food resources for other mammals and birds (carnivores). This group of receptors can be further subdivided into those species that consume primarily fruit (*frugivores*) and nectar (*nectaravores*). In particular avian species that consume nectar are important in the pollination of plants. *Grainivores* – Granivorous wildlife consume primarily seeds. These mammals and birds are important in the dispersal of plants as well as nutrient processing and energy transfer. They also serve as food resources for other mammals and birds (carnivores).
- *Omnivorous Wildlife* – Omnivorous wildlife consume both plant and animals. They are also important in nutrient processing and energy transfer within the terrestrial environment and may serve as food resources for carnivores. Most mammalian and avian species are not strict insectivores or herbivores and instead consume both plant and animal matter usually depending upon the availability of food resources. For risk assessment purposes for evaluating contaminant exposures, mammals and birds are classified into these general groups based on their primary food types. Otherwise most animals would be classified as omnivores.
- *Carnivorous Wildlife* – Carnivorous mammals and birds consume primarily other mammals and birds. Carnivores are important in the control of rodents and other small mammals with high reproductive capacities.
- *Aquatic Invertivores* – Aquatic invertivores are mammals and birds that consume primarily aquatic invertebrates. These organisms are important in the nutrient processing and energy transfer between the aquatic and terrestrial environments. Some avian and bat

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species consume primarily emerging insects and are important in the control of these populations.

- *Piscivores* – Piscivorous mammals and birds consume primarily fish. These organisms are important in the nutrient processing and energy transfer between the aquatic and terrestrial environments.

If a detailed assessment of feeding guilds is needed, the most common approach is to select a representative species to represent the group. The table below is an example of the feeding guilds for which a representative species would be selected. Representative species would be selected based on the chemicals of concern and exposure pathways of concern.

Feeding Guild	Species representative of:
Mammalian Invertivore	Small mammalian species that feed primarily on soil invertebrates
Avian Invertivore	Small avian species that feed primarily on soil invertebrates
Mammalian Omnivore	Small mammalian species that feed primarily on seeds and/or vegetation and some invertebrates.
Avian Omnivore	Small avian species that feed primarily on seeds and/or vegetation and some invertebrates.
Avian Grainivore	Avian species that feed primarily on seeds and grains.
Mammalian Aquatic Invertivore	Mammalian species that feed primarily on aquatic invertebrates.
Avian Aquatic Invertivore	Avian species that feed primarily on aquatic invertebrates.
Mammalian Piscivore	Mammalian species that feed primarily on fish.
Avian Piscivore	Avian species that feed primarily on aquatic fish.

3.4 Exposure Pathways of Chief Concern

Fish

The primary exposure pathway for fish is direct contact with contaminants in surface water. This is applicable to both asbestos and non-asbestos contaminants. Fish may also be exposed to contaminants by ingestion of contaminated prey items, and incidental ingestion of sediment while feeding. Direct contact with sediment may also occur. This is often assumed to be minor compared to the pathways above.

Benthic Invertebrates

Benthic invertebrates may be exposed to contaminants in surface water and/or sediment via ingestion and/or direct contact. Benthic invertebrates may also be exposed to contaminants via

ingestion of aquatic prey items that have accumulated contaminants in their tissues. This is applicable to both asbestos and non-asbestos contaminants.

Terrestrial Plants and Soil Invertebrates

Terrestrial plants and soil invertebrates (e.g., worms) are exposed mainly by direct contact with contaminants in soil. Exposure of plants may also occur due to deposition of contaminated dust on foliar (leaf) surfaces, but this pathway is generally believed to be small compared to root exposure. It is not known whether asbestos in soil is toxic to soil invertebrates such as worms.

Mammals and Birds

Mammals and birds may be exposed to asbestos and non-asbestos contaminants via ingestion of soils, surface water, sediment and food. Mammals and birds may also be exposed to asbestos by inhalation exposures when feeding or foraging activities result in the disturbance of asbestos-contaminated soils, sediments or other media. Direct contact (i.e., dermal exposure) of birds and mammals to soils may occur in some cases, but these exposures are usually considered to be minor in comparison to exposures from ingestion (USEPA, 2003). Likewise, inhalation exposure to non-asbestos contaminants in airborne dusts is possible for all birds and mammals, but this pathway is generally considered to be minor compared to ingestion pathways (USEPA, 2003).

Amphibians

Amphibians inhabit both aquatic and terrestrial environments with early life stages being primarily aquatic and latter life stages primarily terrestrial. Amphibians in their early aquatic life stages may be exposed to contaminants in surface water via ingestion and direct contact. They may also be exposed to contaminants in sediment via ingestion and direct contact and to contaminants in aquatic prey items via ingestion. In the terrestrial environment, amphibians may be exposed to contaminants in soils via ingestion, inhalation and/or direct contact and also as the result of ingestion of terrestrial prey items. Toxicity data for amphibians exposed to contaminants in soils and food are largely not available making it impossible to evaluate the relative contribution of these exposure pathways to the total risk for the receptor.

4.0 MANAGEMENT GOALS AND ASSESSMENT TECHNIQUES

4.1 Management Goals

Management goals are descriptions of the basic objectives which the risk manager wishes to achieve. The overall management goal identified for ecological health at the Libby OU3 site for non-asbestos contamination is:

Ensure adequate protection of ecological receptors within the Libby OU3 Site from the adverse effects of exposures to mining-related releases of asbestos and other chemical contaminants to the environment. "Adequate protection" is generally defined as the reduction of risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota (USEPA, 1999).

In order to provide greater specificity regarding the general management goals and to identify specific measurable ecological values to be protected, the following list of sub-goals was derived:

- Ensure adequate protection of the aquatic communities in Rainy Creek, Fleetwood Creek, the Tailings Impoundment, the Mill Pond, the Carney Creek Pond, and Carney Creek from the adverse effects of asbestos and other site-related contaminants in surface water and sediment.
- Ensure adequate protection of terrestrial plant and soil invertebrate communities within the mined area from the adverse effects of asbestos and other site-related contaminants in soils.
- Ensure adequate protection of the mammalian and avian assessment populations from adverse effects non asbestos contaminants in the mined area and the site drainages, and from the adverse effects of asbestos in the mined area, the site-related drainages and the surrounding forest area.
- Ensure adequate protection of the amphibian assessment population from adverse effects asbestos and non asbestos contaminants in the mined area and the site drainages, and the surrounding forest area.

4.2 Definition of Population

A "population" can be defined in multiple ways. A common definition of the biological population by ecologists is: "A group of plants, animals and other organisms, all of the same species that live together and reproduce. Individual organisms must be sufficiently close geographically to reproduce. Sub-populations are parts of a population among which gene flow is restricted, but within which all individuals have some chance of mating any other individual" (Menzie et al., 2008). "Population" can also be defined differently in the context of a management goal. To prevent miscommunication in risk assessment and risk management, use of the term "assessment population" is recommended (USEPA, 2003). In problem formulation it

is necessary to explicitly state the assessment population(s). The assessment population may be the same as the biological population as defined by ecologists or may be: 1) a component of the biological population (e.g., exposed population); or, 2) a component of relevant meta-population (e.g., a subpopulation).

For the Libby OU3 Site, the assessment populations are defined as the groups of organisms that reside in locations that have been impacted by mining-related releases. For exposure to non-asbestos contaminants, this is believed to be restricted to the mined area and the drainages associated with the mined area. For asbestos, the impacted area may also include surrounding forest lands that were impacted by airborne releases of asbestos. This information will be based on results of the RI, including the spatial pattern of asbestos contamination in forest soils and tree bark.

4.3 Assessment Endpoints

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Because the risk management goals are formulated in terms of the protection of populations and communities of ecological receptors, the assessment endpoints selected for use in this problem formulation focus endpoints that are directly related to population stability. This includes:

- Mortality
- Growth
- Reproduction

Other assessment endpoints may be appropriate, if it is believed that the endpoint can be related to population stability. For example, carcinogenicity might be of concern if it could influence the reproductive potential of a species over its lifetime.

4.4 Measurement Endpoints

Measurement endpoints were initially defined by EPA guidance to represent quantifiable ecological characteristics that could be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (USEPA 1992, 1997). The term measurement endpoint was later replaced with the term *measures of effect* and was supplemented by two other categories of measures (USEPA, 1998). This problem formulation still uses the term measurement endpoint to describe both measures of exposure and effect.

There are a number of different techniques available to ecological risk assessors for measuring the impact of site releases on assessment endpoints and assessing whether or not risk management goals are achieved. The strategies that are available for use at this site are discussed below.

1. The Hazard Quotient (HQ) Approach

A Hazard Quotient (HQ) is the ratio of the estimated exposure of a receptor to a "benchmark" that is believed to be without significant risk of unacceptable adverse effect:

$$\text{HQ} = \text{Exposure} / \text{Benchmark}$$

Exposure may be expressed in a variety of ways, including:

- Concentration of a contaminant in an environmental medium (water, sediment, diet and soil)
- Concentration of a contaminant in tissue
- Amount of a contaminant that is ingested by a receptor

In all cases, the exposure and benchmark must be expressed in like units. For example, exposure in surface water (mg/L) must be compared to a benchmark in mg/L. If the value of an HQ is less than 1E+00, risk of unacceptable adverse effects in the exposed individual is judged to be acceptable. If the HQ exceeds 1E+00, the risk of adverse effect in the exposed individual is of potential concern.

However, not all HQ values are equally reliable as predictors of effect. Interpretation of the ecological consequences of HQ values that exceed 1.0 depends on the species being evaluated and on the toxicological endpoint underlying the toxicity benchmark. In most cases, the benchmark values used to compute HQ values are not based on site-specific toxicity data, and do not account for site-specific factors that may either increase or decrease the toxicity of the metals compared to what is observed in the laboratory. In addition, benchmark values are often not available for the species of feeding guild of concern, so values are extrapolated from other similar types of receptors. Consequently, most HQ values should be interpreted as estimates rather than precise predictions.

2. Site-Specific Toxicity Tests (SSTT)

Site-specific toxicity tests measure the response of receptors that are exposed to site media. This may be done either in the field or in the laboratory using media collected from the site. The chief advantage of this approach is that site-specific conditions which can influence toxicity are usually accounted for, and that the cumulative effects of all contaminants in the medium are evaluated simultaneously. One potential limitation of this approach is that, if toxic effects are observed to occur when test organisms are exposed to site media, it is usually not possible to specify which contaminant or combination of contaminants is responsible for the effect without further testing or evaluation. A second limitation is that it may be difficult to perform tests on site samples that reflect the full range of environmental conditions which may occur in the field across time and space.

3. Population and Community Demographic Observations (PCDO)

Another approach for evaluating possible adverse effects of environmental contamination on ecological receptors is to make direct observations on the receptors in the field, seeking to determine whether any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, benthic organisms, birds) is different than expected. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (non-impacted) abundance and diversity should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. However, it is sometimes quite difficult to locate reference areas that are truly a good match for all of the important habitat variables at the site, so comparisons based on this approach do not always establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a receptor population.

4. In-Situ Measures of Exposure and Effects (IMEE)

An additional approach for evaluating the possible adverse effects of environmental contamination on ecological receptors is to make direct observations on receptors in the field, seeking to identify if individuals have higher exposure (tissue) levels, observed lesions and/or deformities that are higher than expected. This method has the advantage of integrating most (if not all) factors that influence the bioavailability of contaminants in the field. The limitations of this method may be in the interpretation of the consequences of the measured exposure or effect (if suitable toxicity information are not available) and if an appropriate reference population for comparison is available.

It is important to note that the choice of which one or more of these basic approaches is needed or useful in the assessment process may vary between sites, receptors groups, and contaminant types. Section 5 presents the sequence of assessment steps that will be used to evaluate risks to ecological receptors from non-asbestos contaminants, and Section 6 describes the strategy that will be used to evaluated ecological risks from asbestos.

5.0 ASSESSMENT OF RISKS FROM NON-ASBESTOS CONTAMINANTS

5.1 Overview of the Assessment Strategy

Figure 5-1 provides a flow diagram that outlines the basic strategy that will be used to assess risks from non-asbestos contaminants to terrestrial receptors (plants, wildlife) at the mine site and to aquatic receptors (fish, invertebrates) in the surface water drainages associated with the mine. Each of the steps is described below.

Toxicity Assessment

The first step in the assessment of each contaminant is to determine if a relevant and appropriate benchmark or toxicity reference value (TRV) exists for the chemical. If so, the chemical is carried to the initial HQ Screening step (below). If there is no benchmark or TRV available, the next step is to determine if the chemical is present at levels similar to an appropriate background or reference area. If so, no further assessment is needed. If the chemical is present at a level that appears to be elevated over background, then the chemical may be evaluated using one or more non-HQ lines of evidence, or may be identified as a source or uncertainty.

Initial HQ Screen

For non-asbestos analytes that have an appropriate benchmark or TRV, the HQ approach will be the first line of assessment for all receptor groups. This will begin with a screening-level HQ assessment for each analyte in each medium. In this step, a maximum HQ value (HQ_{max}) will be calculated for each medium for each receptor group exposed to the medium, based on the highest detected level of each chemical in each medium. If the maximum concentration does not exceed 1.0, it will be concluded that risks from that chemical in that medium to that receptor group are of minimal concern and that further assessment is not required.

Refined Screen

If the potential for concern for a chemical in a medium can not be excluded based on the initial HQ screen, then a refined HQ screen will be performed. This will include recalculation of HQ values based on a refined estimate of the exposure concentration (rather than just a maximum value), as well as use of refined receptor-specific exposure parameters and toxicity values (when available). The refined screen results will be evaluated by considering the frequency and magnitude of HQ exceedences, and by reviewing the spatial pattern of exceedences. If the magnitude and frequency of HQ exceedences is low, and the data do not suggest there are any localized areas of concern, then further assessment will generally not be required.

Comparison to Background

If further assessment is required, the concentration levels seen in site samples will be compared using appropriate statistical methods to concentrations that are judged to be representative of background (natural) conditions in the area. This is most important for metals, since metals occur naturally in soil and water. It may also be useful for some organic compounds that occur naturally (alkanes, PAHs, etc.). If site levels appear to be similar to natural background levels, further assessment will not be required. If site levels appear to be elevated above natural background, the further assessment may be warranted, as described below.

Other Lines of Evidence

If the potential for concern for a chemical in a medium can not be excluded based on the steps above, then the utility of obtaining data from other lines of investigation will be considered. This may include site-specific toxicity tests and/or community surveys. These tests, if needed, are most likely to be useful for evaluation of risks to fish from surface water, risks to benthic invertebrates from sediment, and risks to plants and soil invertebrates from soil. Further assessment of risks to wildlife receptors, if needed, may conceptually use the same techniques (site-specific toxicity testing, community surveys), although implementing these techniques for wildlife is somewhat more difficult for birds and mammals than for aquatic receptors.

5.2 Initial Screen Results Based on Phase I Data

As noted in Section 2, one round of environmental sampling (referred to as Phase I) of surface water, sediment and on-site soils has been completed at the site in the fall of 2007. These data include measurements of a wide range of non-asbestos analytes, including metals, VOCs, SVOCs, PAHs, PCBs, pesticides, radionuclides, nitrogen compounds, and anions.

It is important to note that the Phase I data alone are not considered sufficient to support the HQ-based assessment steps or background comparison step shown in Figure 5-1 because the data represent only one point in time, and may not fully capture either temporal or spatial variability at the site. For this reason, final implementation of the assessment process will not be performed until two additional rounds of environmental data (scheduled for collection in the spring and summer of 2008) are collected.

Nevertheless, the Phase I data are sufficient to provide an initial impression regarding the potential for concern from non-asbestos contaminants at the site. The results of the initial screening step performed on the Phase I data are presented below.

Surface Water

An initial screening for chemicals of potential concern (COPCs) in surface water was completed by comparing the highest measured concentration of a chemical in surface water to available

aquatic toxicity screening benchmarks. The selected screening benchmarks are described in detail in Attachment C and are listed in Table 2-15. All maximum detected concentrations of metals are lower than respective benchmarks. Benchmarks are not available for either volatile or extractable hydrocarbons. These were detected at three sampling locations two of which are on seeps at Carney Creek (CCS-14 and CCS-11; Figure 2-8) and one is on Fleetwood Creek (FC-2; Figure 2-8).

Sediment

An initial screening for COPCs in sediments was completed by comparing the highest measured concentration of a chemical in sediment to respective sediment toxicity screening benchmarks. The selected screening benchmarks are described in Attachment C and are listed in Table 2-20. Maximum detected concentrations of aluminum, chromium, iron, lead, manganese, nickel, selenium and pyrene exceed respective screening benchmarks based on Threshold Effect Concentrations (TECs), and maximum detected concentrations of chromium, manganese and nickel also exceed respective benchmarks based on Probable Effect Concentrations (PECs). Benchmarks are not available for either volatile or extractable hydrocarbons.

Mine Waste and Soils

An initial screening for COPCs in soils was completed by comparing the highest measured concentration of a chemical in mine waste or soil with respective to available toxicity screening benchmarks for plants, soil invertebrates and wildlife. The selected screening benchmarks are described in detail in Attachment C and are listed in Table 2-23.

For terrestrial plants, mean and maximum detected concentrations of cobalt, copper, manganese, nickel and vanadium are higher than respective toxicity screening benchmarks. For soil invertebrates, the maximum detected concentration of manganese is higher than the toxicity screening benchmark. For wildlife, the mean and maximum detected concentrations of chromium, copper, lead and vanadium are higher than respective toxicity screening benchmarks. The maximum detected concentrations of nickel and zinc also exceed respective benchmarks. All other maximum detected concentrations are lower than respective benchmarks. Benchmarks are not available for either volatile or extractable hydrocarbons or methyl acetate.

Summary

Based on the first round of data collected in the fall of 2007, it is tentatively concluded that risks to ecological receptors are likely to be low for most non-asbestos contaminants, although a few contaminants may be of potential concern and require further assessment. Final decisions about which non-asbestos contaminants may be excluded in the initial screen and which require further assessment will be made after receipt of two additional rounds of data from the spring and summer of 2008.

6.0 ASSESSMENT OF RISKS FROM ASBESTOS

Asbestos is the generic name for the fibrous habit of a broad family of naturally occurring poly-silicate minerals. As noted previously, the Libby vermiculite deposit contains a mixture of amphibole asbestos types, referred to as Libby Amphibole Asbestos (LA). Attachment D provides a review of asbestos mineral logy, fate and transport, analytical measurement techniques, and toxicity.

6.1 Overview of the Assessment Strategy

Conceptually, the process of assessing ecological risks from asbestos might follow the same procedure as used for non-asbestos contaminants (see Figure 5-1). As noted previously, this approach depends upon the availability of relevant and reliable toxicity reference values or benchmarks for the contaminants of potential concern.

However, in the case of asbestos, no toxicity benchmarks have been derived to date for any receptor class, and most of the studies that are available to potentially serve as a basis for a benchmark are based on studies of chrysotile asbestos rather than amphibole asbestos. In particular, there are no studies on the toxicity of LA on any class of ecological receptors. Because of this, it is concluded that available data are not sufficient at present to employ an assessment strategy that is HQ-based. Rather, the strategy for assessing risks from asbestos must be based on information that can be collected from field studies of the following types:

- Site-specific toxicity testing
- Site-specific population surveys
- Site-specific studies of biomarkers of exposure and effect

The detailed assessment strategies planned for aquatic receptors, terrestrial plants and soil invertebrates, and terrestrial wildlife (birds, mammals) are in the following sections.

6.2 Strategy for Assessing Risks to Aquatic Receptors

Site-Specific Toxicity Testing

The first line of evidence for evaluation of risks to aquatic receptors will be site-specific toxicity testing. Figure 6-1 provides a conceptual flow diagram of the approach.

Step 1. Collect surface water from multiple on-site locations at a time when concentration of LA are expected to be at their highest (during the peak of spring runoff) and an upstream Rainy Creek location as a local frame of reference.

Step 2. Evaluate the toxicity of each water (undiluted) to an appropriate aquatic species (e.g., rainbow trout) of an appropriate age class (e.g., larvae).

Step 3a. If toxicity is seen in one or more waters, use the data to estimate a site-specific exposure-response curve. In addition, select the water with the highest toxicity (highest concentration) and repeat the toxicity tests on a dilution series of that water. The purpose is to further support an empiric site-specific exposure-response curve for LA. This study would also include measurements of tissue burden (fibers/gram tissue) and the occurrence of histopathological lesions. These data will help establish a firm foundation for extrapolation of exposure response data from the laboratory to the field.

Step 3b. If no toxicity is observed in any site water, perform a study in which LA is added to water to yield concentrations even higher than achieved in the site waters. If toxicity is seen in this spiking study, the data can be used to derive a site-specific exposure-response curve for LA. As above, this study would also include collection of data on tissue burden and histopathological lesions in the exposed organisms.

The protocol for the site-specific toxicity testing will be based on the methods used by Belanger (1985). In brief, the study will be conducted using rainbow trout larva. The same approach may be followed using other aquatic species, as deemed appropriate. Exposure will occur in three 4-L aquaria, each containing 15 larva. Air bubblers will be used to ensure that asbestos particles in the water remain suspended. The water will circulated continuously (without filtration), and will be changed weekly. Endpoints will include qualitative observations on feeding and swimming behavior, and quantitative data on mortality and growth.

The first line of evidence for the assessment of risks associated with asbestos in sediment will also be site-specific toxicity testing. Figure 6-2 provides a conceptual flow diagram for how this will be done. As shown, the approach is similar to that for surface water, except that the site-specific exposure response curve can be developed based on site samples with a dilution series because the samples selected for testing can be chose to reflect the range of values seen on-site, from lowest to highest.

Population and Community Demographic Observations

The second line of evidence for evaluation of risks for aquatic receptors is the collection of data on the density and diversity of receptors (fish and/or benthic organisms) in site waters and comparison to appropriate reference locations. This type of data is a valuable independent line of evidence to be used in conjunction with the toxicity testing data. The collection of population and community demographic information will be performed as follows:

Benthic Invertebrate Community. Benthic invertebrate community structure and function will be measured at stream locations on upper and lower Rainy Creek, Carney Creek and Fleetwood Creek. Benthic invertebrate samples will be collected at the same locations as sediment and surface water samples. Samples will be collected according to an established EPA *Rapid Bioassessment Protocol* (RBP) (USEPA, 2003). For each

sampling location, a number of alternative metrics of benthic community status will be calculated and combined to yield a Biological Condition Score. A number of alternative measures of habitat quality will also be measured to yield a Habitat Quality Score (a comparison of the Biological Condition Score to the Habitat Quality Score provides information on the likely contribution of non-habitat factors (e.g., chemical pollution) on the benthic community). The scores and individual metrics will be examined to identify if the community is impacted relative to reference and if there are any apparent trends in condition with asbestos concentrations. This method will require location of appropriate reference areas for comparison. The reference area(s) should match as closely as possible the habitat variables present at the aquatic sites being evaluated. As asbestos contamination may have been transported from the mine site area to upstream locations in Rainy Creek, upstream locations are not an appropriate reference.

Fish Community. Fish community will be assessed at all ponds and a sub-sample of the stream sampling locations using standard electrofishing techniques. Fish species and number (density) will be measured and compared to matched reference locations.

In-Situ Measures of Exposure and Effects

Fish will be collected from the site and reference areas to assess the level of exposure via measures of asbestos body burden and the level of effect via the frequency and severity of histological lesions. On-site collection locations will be selected based on the results of the site-specific toxicity testing, community survey and the measurement of LA in water and sediment, with an emphasis on sampling from locations with maximum concentration and/or toxicity.

Tissue Burden

Measurements of LA tissue burden in fish will be performed on whole body and/or on selected organs (e.g. gill). In brief, tissue to be analyzed will be weighed (wet weight) and then dried and ashed. The ashed residue will be resuspended in acid and water and an aliquot will be deposited on a filter for analysis by TEM. Results will be expressed as fibers of LA per gram (wet weight) of tissue.

Gross and Microscopic Lesions

Fish collected from the field and reference locations will be examined for gross pathology, pathology effects and histological effects. Lesions that have been reported in the literature following exposure of aquatic organisms to asbestos are summarized in Table 6-1. Incidence and severity of effects observed in fish from on-site locations will be compared to a reference area, and also to the concentrations of asbestos in surface water and sediment at the sampling stations in an effort to establish a dose-response relationship. Consequences of the measured pathology effects will be evaluated based on literature information that associates the pathology

effects with adverse effects on growth reproduction and survival. However, the evaluation of ecological consequences may be limited by the small number of samples available.

6.3 Strategy for Assessing Risks to Terrestrial Plants and Soil Invertebrates

For the purposes of assessing risks to plants and soil invertebrates (e.g., worms), the site will be divided into two main parts: the on-site mined area and the surrounding forested area. At present, no assessment will be performed on the mined area. This is because the mined area has been and continues to be disturbed by heavy machinery, as well as the placement of piles of waste rock that are unlikely to be suitable for plant growth. If an evaluation of LA toxicity is needed in on-site soils, this will be undertaken at the level of the Feasibility Study (FS). The approach for evaluating risks to plants and soil invertebrates in the forest area surrounding the site is presented below.

Site-Specific Toxicity Testing

The first line of evidence for assessment of risks to terrestrial plants and soil invertebrates in off-site soils will be site-specific toxicity testing of soils collected from areas near the mined area. The exact choice of soils will be based on the Phase I forest soil data (see Figure 2-14), and will include a range of LA levels from ND (not detected) to the highest values observed (6%). Testing will be completed using standard laboratory test organisms using established protocols for chronic endpoints (growth, reproduction and survival). If toxicity is observed, the data will be used to derive site-specific toxicity values for plants and soils invertebrates for LA.

Site-Specific Population and Community Demographic Observations

For soil invertebrates, methods for measurement of community demographic information are not very well established, and the results are often difficult to interpret, especially for U.S. western soils. Therefore, it is considered likely that this assessment tier will not be implemented for soil invertebrates.

In contrast methods are well established for assessment of the density and diversity of terrestrial plant communities, and application of these methods may be useful for evaluating whether plant communities near the mine area are observably different than in appropriate reference locations.

6.4 Strategy for Assessing Risks to Terrestrial Birds and Mammals

Asbestos is found in soils across the mine site area, as well as in the surface waters and sediments of the Rainy Creek drainage. Although data from Phase I are not yet available, it is considered likely that asbestos also contaminates trees and soils in forested areas for some distance away from the mine site.

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Exposures for wildlife species are expected for each of these media via ingestion. Wildlife may also be exposed via inhalation to soils, sediments that have dried and also fibers deposited on foliar surfaces and trees. The extent of inhalation exposures; however, are based on activities that disturb the deposited asbestos and result in emissions into the air. Activities by wildlife that may result in disturbance include foraging on the ground, nesting on the ground, burrowing, and foraging in trees and foliage.

Biomarkers of Exposure and Effect

The first line of evidence for assessment of risks for wildlife is the measurement of biomarkers of exposure and effect in organisms collected from the site. This technique has the advantage that it allows an assessment of exposure and effects by both oral and inhalation exposures, and may allow development of maps that indicated the relative levels of exposure as a function of location. The chief disadvantage of this method is that biomarkers of exposure and effect are not easy to extrapolate to effects on growth, reproduction and survival, and hence on population stability.

Indicator Species

In order to implement this approach, it is first necessary to identify the classes of wildlife that are likely to be maximally exposed. The most important selection criteria include the following:

- Non-transitory. Some organisms migrate over long distances, and are present in the area of the site for only a short time each year. Because of the brief interval they would be exposed, such organisms would have less exposure than organisms that are present year round or for most of the breeding season.
- Small home range. Organisms that have a large home range are likely to spend a small part of their time in and about the most heavily impacted areas of the site. Consequently, they are likely to be less exposed than organisms that have a small home range and spend a high fraction of their time in and about the impacted areas.

In addition to these two baseline factors, there are a number of other factors that may also influence the relative level of exposure, including the following:

- Foraging strategy – Species that forage on the ground and have a greater potential to disturb asbestos fibers are expected to have more inhalation exposure than those that forage in shrubs or tree foliage. Species that feed in flight on insects and carnivores that prey on other mammals and birds are expected to be less exposed. Species that forage on aquatic organisms and fish would also be less exposed because inhalation exposures require the disturbance of fibers which is less likely under wet conditions.

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- Habitats and Nesting – Where species find shelter, give birth (or nest) and/or rear young may also influence exposures. Many species burrow into the ground or create shallow runs under forest litter. Some others will create nests/dens in existing cavities of barren rock or dead trees. Burrowers are expected to receive higher exposures compared to those species that live higher in trees.
- Body Size – Ingestion rates and breathing rates per unit body weight tend to be higher for species with small body weights compared to species with higher body weights. Thus, exposure by both oral and ingestion pathways may be highest for small receptors.
- Longevity In humans, it is well established that risk of adverse effects is a function of cumulative exposure. That is, risk depend both on exposure level and also on exposure duration. For this reason, organisms that have longer life spans will tend to have higher cumulative exposures and hence may be more likely to display adverse effects from asbestos exposure.

Taking these factors into account, the feeding guilds and species identified as residing within the area of Libby OU3 (listed in Attachment A) were evaluated in order to identify a list of receptors most likely to have high exposures to LA, as follows:

- 1) Species inhabiting terrestrial and riparian habitats were segregated into two groups based on habitat type (terrestrial and riparian).
- 2) As exposures to asbestos for species inhabiting riparian habitats are primarily related to ingestion of aquatic food items as well as surface water and sediments, the riparian species were segregated into two exposure groups by feeding guild. These include aquatic invertivores/omnivores and piscivores.
- 3) For species that inhabit terrestrial habitats, those that forage on the ground and or inhabit nests or burrows were identified from the larger list and classified into a “ground” foraging group. These species are expected to be the highest exposed to asbestos via inhalation and ingestion as a result of probing and disturbing asbestos in soils and ground litter.
- 4) Species that forage primarily in trees and shrubs were identified from the larger list and classified as an “arboreal” foraging group. These species may be exposed to asbestos on tree bark or leaf surfaces as result of foraging for food.
- 5) Carnivorous species were identified and placed in separate group based on feeding guild. These species are expected to be exposed to asbestos primarily via ingestion and inhalation exposures are expected to be lower than those species that forage on the ground for food.
- 6) The ground and arboreal groups were further stratified into feeding guilds (invertivore, grainivore, omnivore, carnivore) to reflect exposures related to ingestion.
- 7) The species in each group were then reviewed further and those with small home ranges and small body sizes were selected preferentially. These species are expected to be maximally exposed to asbestos impacted area and will not range in and out of the area.

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Potential exposures and risks for the larger animal species will be considered at a later time based on the results for the smaller more exposed species.

- 8) For avian species, birds that are transients (occurring at the site only during spring or fall migrations) were excluded, while birds that are resident year round or are present for extended periods during the warm weather were retained.

Table 6-2 provides the list of species that meet the selection criteria above. The following table summarizes the categories of receptor groups that are likely to be maximally exposed in each exposure area.

Location	Exposed Receptor Group	Exposure
Mined area and Forest area	Ground Invertivore	Ingestion of asbestos in soil invertebrates and inhalation of asbestos in soil during disturbance.
	Ground Herbivore/Omnivore	Ingestion of asbestos in/on plant material and inhalation of asbestos in soil during disturbance.
Forest area	Arboreal Invertivore	Ingestion and inhalation of asbestos on tree bark and/or vegetation.
Riparian area	Aquatic Invertivore/Omnivore	Ingestion of asbestos in aquatic plants and aquatic invertebrates.
	Piscivore	Ingestion of asbestos in fish.

Collection Methods

Birds and mammals will be collected from each of the areas (mined, forest and riparian) as well as matched reference areas. Mammals will be collected by the use of Sherman live traps. Birds will be collected by the use of mist nets or other appropriate methods. Birds in the riparian areas (ducks) will be collected by shot.

Measurement of Asbestos Tissue Burdens

Asbestos tissue burdens in selected organs (lungs and gastrointestinal tract) of animals collected at the site will be analyzed for asbestos tissue burden. Tissue burden in lung will be interpreted as an indication of inhalation exposure, and tissue burden in the GI tract and kidneys will be taken as an indication of oral exposure. Comparison of the data from on-site locations and reference locations will be used to establish an empiric estimate of the spatial extent where LA exposures can be recognized as being higher than background.

Histopathology

Asbestos exposures in mammals are known to be associated with certain pathology effects. A large number of studies have been performed in mammals to identify the effects of asbestos on the respiratory tract, and to a lesser degree on other organs (e.g. gastrointestinal tract). In animals, histological signs of tissue injury can be detected at the site of deposited fibers within a

few days (ATSDR 2001). Ingestion exposures have been associated with lesions in the parathyroid tissue, brain tissue, pituitary tissue, endothelial tissue, kidney tissue, and peritoneum tissue (Cunningham et al., 1977). Induction of aberrant crypt foci in the colon (Corpet et al., 1983) and tumors of the gastrointestinal tract have also been reported. Inhalation exposures are associated with fibrosis, lung tumors and lesions along the respiratory bronchioles, alveolar ducts, alveoli, and lung tissue (McGavran et al. 1989; Donaldson et al. 1988; Davis et al., 1980a, 1980b, 1985, 1986). Mesotheliomas have been observed (Davis and Jones 1988, Davis et al. 1985, Wagner et al. 1974, 1980, Webster et al. 1993). The histopathological effects of asbestos exposures in avian species is not known.

Organisms collected from site locations (on-site, forest area, riparian area) will be examined for gross and microscopic pathological effects. The incidence and severity of effects observed will be compared to organisms from suitable reference areas, and will also be correlated with the relative concentrations of LA in the collection area. These data, combined with the tissue burden data, will help define the spatial extent of LA contamination that can impact wildlife. Interpretation of the ecological consequences of any gross or histological lesions that are observed will be based on literature information that associates the pathology effects with adverse effects on growth, reproduction, and survival, as well as on consultation with experts in the field.

Population and Community Demographic Observations

A second line of evidence for the assessment of risks for wildlife will be the collection of population and community demographic observations. Quantitative surveys of mammalian and avian density and diversity are difficult to perform, and will not be attempted in a formal fashion at this time. However, semi-quantitative data in the form of number of organisms of each species collected per trapping day will be available from the field collection effort for both on-site locations and reference locations. Comparison of these trapping rates will provide an initial impression as to whether population densities are likely to be similar or dissimilar in site areas compared to reference areas. If evidence of an apparent difference is obtained, this may be followed with more quantitative efforts to compare population demographics, depending on the overall weight of evidence available.

Additional Toxicity Testing with LA

Based on the results of the lines of evidence described above, further studies of LA exposure and effect in birds and/or mammals may be considered. This testing may be used to identify dose-response values for growth, reproduction or survival effects in birds or evidence of physiological stress.

6.5 Strategy for Assessing Risks to Amphibians

Site-Specific Toxicity Testing

The first line of evidence for the assessment of risks to amphibians from contact with site surface water will be site-specific toxicity testing. The test will be performed as follows:

Step 1. Collect surface water from multiple on-site locations focusing on ponded areas and seeps where amphibians are expected to occur.

Step 2. Evaluate the toxicity of each site collected water (undiluted)

Step 3a. If toxicity is seen in one or more waters, use the data to estimate a site-specific exposure-response curve. In addition, select the water with the highest toxicity (highest concentration) and repeat the toxicity tests on a dilution series of that water.

Step 3b. If no toxicity is observed in any site water, perform a study in which LA is added to water to yield concentrations even higher than achieved in the site waters. If toxicity is seen in this spiking study, the data can be used to derive a site-specific exposure-response curve for LA.

In brief, the study will be conducted using *Xenopus laevis* using a modification of ASTM E1439-98(2004) Standard Guide for Conducting the Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX). The normal duration of the study (4 days) will be extended to 14 days to allow a longer period of exposure and observation of development. Endpoints evaluated in the study will include mortality, malformations, growth, and development.

The line of evidence for assessment of risks for amphibians to LA in sediment will also be site-specific toxicity testing. The approach is similar to that for surface water, except that the site-specific exposure response curve can be developed based on the site samples with a dilution series because the samples selected for testing can be chosen to reflect the range of values seen on-site, from lowest to highest.

In-Situ Measures of Exposure and Effects

A second line of evidence for assessment of risks for amphibians to LA in surface water and sediment will be the collection of amphibians from the site and from reference areas to examine and assess the frequency and severity of gross and histological abnormalities. This examination may be based on field observations alone, or may include laboratory-based examination of some species. The incidence of effects observed in amphibians collected from the site will be compared to a reference area as well as regional and national statistics in order to judge if there is an effect. If so, the incidence data for abnormalities will be correlated with the

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concentrations of LA in surface water and sediment at the sampling stations in an effort to establish a dose-response relationship.

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TABLES

Table 2-1
Climate Data for Libby NE Ranger Station (245015)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	31.6	40.1	50.1	61.7	71.1	78.4	87.9	86.8	75	59	40.5	32.1	59.5
Average Min. Temperature (F)	15.7	19.1	24.4	30.2	36.9	43.3	46.2	44.5	38.4	32.3	25.5	18.9	31.3
Average Total Precipitation (in.)	2.03	1.39	1.31	1.01	1.39	1.59	0.87	0.94	1.18	1.56	2.26	2.3	17.84
Average Total SnowFall (in.)	17.4	7.6	3.9	0.3	0	0	0	0	0	0.5	6.5	17.8	54
Average Snow Depth (in.)	9	9	4	0	0	0	0	0	0	0	2	5	2

Source: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?mtlibb>

Table 2-2
Stream Use Classifications

Stream/Segment	Classification/Uses
Rainy Creek drainage upstream of the W.R. Grace Company water supply intake	A-1. Suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and fur bearers; and agricultural and industrial water supply.
Rainy Creek (mainstem) from the W.R. Grace Company water supply intake to the Kootenai River	C-1. Suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
Kootenai River	B-1. Suitable for drinking, culinary and food processing purposes; propagation of salmonid fishes and associated aquatic life, waterfowl and fur bearers; and agricultural and industrial and industrial water supply.

Table 2-3. The classification system used to map Montana's existing vegetation and land cover.

I. Urban and Agricultural Lands

- 1100 Urban or Developed Lands
- 2010 Agricultural Lands - Dry
- 2020 Agricultural Lands - Irrigated

II. Grasslands

herbaceous cover > 15%, shrub cover < 15%, and forest cover < 10%

- 3110 Altered Herbaceous
- 3130 Very Low Cover Grasslands
- 3150 Low / Moderate Cover Grasslands
- 3170 Moderate / High Cover Grasslands
- 3180 Montane Parklands & Subalpine Meadows

III. Shrublands

shrub cover (SC) > 15% and forest cover < 10%; except 3500 classes where SC = HC

- 3200 Mixed Mesic Shrubs
- 3300 Mixed Xeric Shrubs
- 3309 Silver Sage
- 3310 Salt-Desert Shrub / Dry Salt Flats
- 3350 Sagebrush
- 3510 Mesic Shrub - Grassland Associations
- 3520 Xeric Shrub - Grassland Associations

IV. Forest Lands

forest cover > 10%

- 4000 Low Density Xeric Forest
- 4140 Mixed Broadleaf Forest
- 4203 Lodgepole Pine
- 4205 Limber Pine
- 4206 Ponderosa Pine
- 4207 Grand Fir
- 4210 Western Red Cedar
- 4211 Western Hemlock
- 4212 Douglas-fir
- 4214 Rocky Mountain Juniper
- 4215 Western Larch
- 4216 Utah Juniper
- 4223 Douglas-fir / Lodgepole Pine
- 4260 Mixed Whitebark Pine Forest
- 4270 Mixed Subalpine Forest
- 4280 Mixed Mesic Forest
- 4290 Mixed Xeric Forest
- 4300 Mixed Broadleaf & Conifer Forest
- 4400 Standing Burnt Forest

V. Water

- 5000 Water

VI. Riparian Types

sites clearly associated with riparian areas or woody draws

- 6110 Conifer Riparian
- 6120 Broadleaf Riparian
- 6130 Mixed Broadleaf & Conifer Riparian
- 6200 Graminoid & Forb Riparian
- 6300 Shrub Riparian
- 6400 Mixed Riparian

VII. Barren Lands

sites with forest cover < 10%, shrub cover < 10%, and herbaceous cover < 10%

- 7300 Rock
- 7500 Mines, Quarries, Gravel Pits
- 7600 Badlands
- 7604 Missouri Breaks
- 7800 Mixed Barren Sites

VIII. Alpine

vegetated sites above treeline

- 8100 Alpine Meadows

IX. Perennial Snow and Ice

- 9100 Snowfields or Ice

X. Other

- 9800 Clouds
 - 9900 Cloud Shadows
-

Table 2-4
Aquatic Invertebrate Species Collected from EMAP Sampling Location in Kootenai River (August 2002)

PHYLUM	CLASS	ORDER	FAMILY	GENUS	SPECIES	ABUND.
ANNELIDA	HIRUDINEA	RHYNCHOBDELLIDA	PISCICOLIDAE	NA	NA	1
	OLIGOCHAETA	NA	NA	NA	NA	59
ARTHROPODA	ARACHNIDA	TROMBIDIFORMES	HYGROBATIDAE	HYGROBATES	NA	1
	INSECTA	DIPTERA	TORRENTICOLIDAE	TORRENTICOLA	NA	3
			CHIRONOMIDAE	NA	NA	8
				CRICOTOPUS	BICINCTUS	20
				CRICOTOPUS	NA	17
				CRYPTOCHIRONOMUS	NA	1
				DICROTENDIPES	NA	3
				EUKIEFFERIELLA	NA	8
				MICROPSECTRA	NA	16
				NA	NA	85
				PAGASTIA	NA	10
				PARACHIRONOMUS	NA	7
				PARAKIEFFERIELLA	NA	4
				NA	NA	1
				PHAENOPSECTRA	NA	57
				POTTHASTIA	GAEDII	2
				POTTHASTIA	LONGIMANA	7
				PROCLADIUS	NA	1
				PSECTROCLADIUS	NA	1
				SYNORTHOCLADIUS	NA	7
				TANYTARSUS	NA	73
				THIENEMANNIMYIA	NA	7
				TVETENIA	DISCOLORIPES	17
			TIPULIDAE	TIPULA	NA	1
		EPHEMEROPTERA	BAETIDAE	BAETIS	NA	10
				BAETIS	TRICAUDATUS	17
			EPHEMERELLIDAE	DRUNELLA	GRANDIS	1
				EPHEMERELLA	NA	13
				SERRATELLA	TIBIALIS	2
			SIPHONURIDAE	NA	NA	1
		HEMIPTERA	CORIXIDAE	NA	NA	18
		TRICHOPTERA	HYDROPTILIDAE	HYDROPTILA	NA	3
			LEPTOCERIDAE	MYSTACIDES	ALAFIMBRIATA	1
				OECETIS	NA	1
			LIMNephilidae	NA	NA	1
				PSYCHOGLYPHA	NA	1
	OSTRACODA	NA	NA	NA	NA	1
COELENTERATA	HYDROZOA	HYDROIDA	HYDRIDAE	HYDRA	NA	12
MOLLUSCA	GASTROPODA	BASOMMATOPHORA	LYMNAEIDAE	NA	NA	1
			LYMNAEIDAE	STAGNICOLA	NA	2
			PHYSIDAE	PHYSA	NA	7
NEMATODA	NA	NA	NA	NA	NA	2

Table 2-5
Fish Species Collected from EMAP Sampling Location
in Kootenai River (August 2002)

Common Name	Genus	Species	Abundance
Longnose Dace	<i>Catostomus</i>	<i>catostomus</i>	24
Largescale Sucker	<i>Catostomus</i>	<i>macrocheilus</i>	21
Slimy Sculpin	<i>Cottus</i>	<i>cognatus</i>	1
Torrent Sculpin	<i>Cottus</i>	<i>rhotheus</i>	2
Cutthroat trout	<i>Oncorhynchus</i>	<i>clarki</i>	4
Rainbow trout	<i>Oncorhynchus</i>	<i>mykiss</i>	39
Sockeye Salmon	<i>Oncorhynchus</i>	<i>nerka</i>	17
Mountain Whitefish	<i>Prosopium</i>	<i>williamsoni</i>	587
Longnose Dace	<i>Rhinichthys</i>	<i>cataractae</i>	1
Redside Shiner	<i>Richardsonius</i>	<i>balteatus</i>	9
Bull Trout	<i>Salvelinus</i>	<i>confluentus</i>	1

TABLE 2-6
FEDERAL LISTED SPECIES THAT HAVE BEEN OBSERVED IN OU3

Group	Common Name (<i>Genus species</i>)	Rank
Fish	White Sturgeon (<i>Acipenser transmontanus</i>) (Kootenai River Pop.)	LE
	Bull Trout (<i>Salvelinus confluentus</i>)	LT, CH
Birds	Bald Eagle (<i>Haliaeetus leucocephalus</i>)	LT
Mammals	Grizzly Bear (<i>Ursus arctos horribilis</i>)	LT
	Gray Wolf (<i>Canis lupus</i>)	LE
	Canada Lynx (<i>Lynx canadensis</i>)	LT
<p>LE = Listed endangered - Any species in danger of extinction throughout all or a significant portion of its range (16 U.S.C. 1532(6)).</p> <p>LT = Listed threatened - Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (16 U.S.C. 1532(20)).</p> <p>CH = Critical Habitat - The specific areas (i) within the geographic area occupied by a species, at the time it is listed, on which are found those physical or biological features (I) essential to conserve the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by the species at the time it is listed upon determination that such areas are essential to conserve the species.</p> <p>C = Candidate - Those taxa for which sufficient information on biological status and threats exist to propose to list them as threatened or endangered.</p>		

TABLE 2-7.
STATE SPECIES OF CONCERN THAT HAVE BEEN OBSERVED IN OU3

Group	Common Name (<i>Genus species</i>)	Rank
Amphibians	Coeur d'Alene Salamander (<i>Plethodon idahoensis</i>)	S2
	Boreal Toad, Green (also known as Western Toad) (<i>Bufo boreas</i>)	S2
Birds	Bald Eagle (<i>Haliaeetus leucocephalus</i>)	S3
	Black-backed Woodpecker (<i>Picoides arcticus</i>)	S2
	Flammulated Owl (<i>Otus flammeolus</i>)	S3B
	Harlequin Duck (<i>Histrionicus histrionicus</i>)	S2B
	Lewis's Woodpecker (<i>Melanerpes lewis</i>)	S2B
	Northern Goshawk (<i>Accipiter gentilis</i>)	S3
	Olive-sided Flycatcher (<i>Contopus cooperi</i>)	S3B
Mammals	Fisher (<i>Martes pennanti</i>)	S3
	Gray Wolf (<i>Canis lupus</i>)	S3
	Grizzly Bear (<i>Ursus arctos horribilis</i>)	S2S3
	Lynx (<i>Lynx canadensis</i>)	S3
Fish	Bull Trout (<i>Salvelinus confluentus</i>)	S2
	Torrent Sculpin (<i>Cottus rhotheus</i>)	S3
	Westernslope Cutthroat Trout (<i>Oncorhynchus clarkii lewisi</i>)	S2
Invertebrates	Stonefly (<i>Utacapnia columbiana</i>)	S2
	Slug, Magnum Mantleslug (<i>Magnipelta mycophaga</i>)	S1S3
	Slug, Pygmy Slug (<i>Kootenaia burkei</i>)	S1S2
	Land Snail, Robust Lancetooth (<i>Haplotrema vancouverense</i>)	S1S2
	Slug, Sheathed Slug (<i>Zacoleus idahoensis</i>)	S2S3
	Land Snail, Smoky Tailedropper (<i>Prophysaon humile</i>)	S1S3
	Land Snail, Striate Disc (<i>Discus shimekii</i>)	S1

S1 = At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.
 S2 = At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to global extinction or extirpation in the state.
 S3 = Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas.

Table 2-8. Phase I Asbestos Results for Surface Water

Reach	Station	Index ID	Volume Examined (mL)	Sensitivity 1/L	Total LA		LA > 10 µm in length	
					Count	Conc (MFL)	Count	Conc (MFL)
Upper Rainy Creek	URC-1	P1-00391	0.0090	1.11E+05	0	<0.1	0	<0.11
	URC-2	P1-00390	0.0090	1.11E+05	52	5.8	1	0.1
Tailings Impoundment	TP	P1-00269	0.0005	1.99E+06	57	114	19	38
	TP-TOE1	P1-00254	0.0200	5.00E+04	0	<0.1	0	<0.1
	TP-TOE2	P1-00312	0.0050	1.99E+05	10	2.0	6	1.2
Mill Pond	MP	P1-00313	0.0020	4.98E+05	54	27	20	10
Lower Rainy Creek	LRC-1	P1-00304	0.0201	4.98E+04	4	0.2	0	<0.05
	LRC-2	P1-00251	0.0201	4.98E+04	2	0.1	1	0.05
	LRC-3	P1-00303	0.0201	4.98E+04	4	0.2	0	<0.05
	LRC-4	P1-00302	0.0201	4.98E+04	21	1.0	3	0.1
	LRC-5	P1-00301	0.0201	4.98E+04	25	1.2	2	0.1
	LRC-6	P1-00300	0.0200	5.00E+04	0	<0.1	0	<0.1
Fleetwood Creek	FC-1	P1-00267	0.0131	7.66E+04	51	3.9	12	0.9
	FC-Pond	P1-00266	0.0004	2.49E+06	50	125	3	7.5
	FC-2	P1-00268	0.0201	4.98E+04	4	0.2	1	0.05
Carney Creek	CC-1	P1-00381	0.0211	4.74E+04	20	0.9	7	0.3
	CC-2	P1-00380	0.0201	4.98E+04	1	0.05	1	0.05
Seeps	CCS-9	P1-00315	0.0200	5.00E+04	0	<0.1	0	<0.1
	CCS-8	P1-00317	0.0200	5.00E+04	0	<0.1	0	<0.1
	CCS-6	P1-00385	0.0005	1.99E+06	50	100	2	4.0
	CCS-1	P1-00382	0.0070	1.42E+05	53	7.5	3	0.4
	CCS-11	P1-00383	0.0030	3.32E+05	50	17	10	3.3
	CCS-14	P1-00265	0.0050	1.99E+05	55	11	0	<0.2
	CCS-16	P1-00316	0.0125	8.00E+04	0	<0.1	0	<0.1

DRAFT RESULTS PENDING VALIDATION

Table 2-9. Asbestos Results for Sediment

Reach	Station	Index ID	MASS (grams)		RESULTS	
			Fine Fraction	Coarse Fraction	MF _{LA%} fine	MF _{LA%} coarse
Upper Rainy Creek	URC-1	P1-00409	137.7	0	ND	--
	URC-2	P1-00408	123.1	47.9	<1%	Tr
Tailings Impoundment	TP	P1-00407	100.2	6.6	<1%	Tr
	TP-TOE1	P1-00326	142.2	30.6	2%	0.38%
	TP-TOE2	P1-00325	183.2	29	3%	0.03%
Mill Pond	MP	P1-00348	166.7	0	<1%	--
Lower Rainy Creek	LRC-1	P1-00338	210.9	44.7	<1%	0.13%
	LRC-2	P1-00336	256.9	36.2	<1%	Tr
	LRC-3	P1-00335	98.86	0	2%	--
	LRC-4	P1-00329	137.8	0	<1%	--
	LRC-5	P1-00328	129.8	35	<1%	Tr
	LRC-6	P1-00327	183.5	0	<1%	--
Fleetwood Creek	FC-2	P1-00406	203.7	14.3	Tr	ND
	FC-Pond	P1-00405	89.2	0	<1%	--
	FC-1	P1-00404	200.9	31.2	ND	ND
Carney Creek	CC-2	P1-00399	153.9	37.4	<1%	0.20%
	CC-1	P1-00395	126.1	28.6	4%	0.52%
Seeps	CCS-9	P1-00400	111.9	8.7	7%	Tr
	CCS-8	P1-00398	75.6	33.6	6%	0.41%
	CCS-6	P1-00397	163.9	21.8	2%	Tr
	CCS-1	P1-00396	170.2	53.3	2%	Tr
	CCS-11	P1-00402	183.3	26.4	<1%	0.20%
	CCS-14	P1-00403	129.6	4.1	<1%	Tr
	CCS-16	P1-00289	119	0	4%	--

Refer to Tech Memo 8 for descriptions of Approach 1 and 2.

ND = not detected

Tr = trace

MF = mass fraction

-- = coarse fraction was not analyzed.

DRAFT RESULTS PENDING VALIDATION

Table 2-10. Asbestos Results for Mine Waste

Sampling Matrix	StationID	IndexID	MASS (grams)		RESULTS	
			Fine Fraction	Coarse Fraction	MF _{LA%} fine	MF _{LA%} coarse
Road	MS-1	P1-00370	124.3	54	<1%	Tr
	MS-2	P1-00371	161.2	19.5	<1%	Tr
	MS-3	P1-00372	164.8	83.3	Tr	Tr
Tailings Impoundment	MS-4	P1-00332	124.1	44	<1%	Tr
	MS-5	P1-00357	133.7	1.41	<1%	Tr
Coarse Tailings	MS-6	P1-00355	174.5	27.8	<1%	0.27%
	MS-7	P1-00294	155.9	32.5	2%	1.00%
	MS-8	P1-00330	130.8	11.8	<1%	Tr
	MS-9	P1-00356	143.1	31	<1%	0.58%
Cover Material	MS-10	P1-00366	184.4	42.8	<1%	0.09%
	MS-11	P1-00367	130.9	12	<1%	0.07%
	MS-12	P1-00369	183.2	23.1	<1%	2.61%
	MS-13	P1-00365	154.7	7.3	Tr	Tr
	MS-21	P1-00378	183.6	5	<1%	Tr
	MS-22	P1-00379	142.8	19.5	<1%	0.43%
	MS-23	P1-00340	103.6	16.3	ND	Tr
	MS-24	P1-00353	149.6	24.4	2%	1.36%
Waste Rock	MS-14	P1-00345	153.4	6.9	<1%	3.70%
	MS-15	P1-00206	142.7	4.5	5%	Tr
	MS-16	P1-00205	192.5	27.5	2%	0.52%
	MS-17	P1-00343	150	26.6	<1%	1.10%
	MS-18	P1-00352	163	15.5	<1%	1.86%
	MS-19	P1-00341	109.8	4	<1%	0.82%
	MS-20	P1-00350	101.9	15.6	<1%	Tr
	MS-26	P1-00292	139.6	30.7	3%	0.21%
	MS-27	P1-00299	172.9	40.8	<1%	1.88%
	MS-28	P1-00290	156.8	22.8	<1%	3.31%
	MS-29	P1-00298	119.2	72.9	2%	1.26%
	MS-30	P1-00342	174.9	27.1	<1%	0.28%
Outcrop	MS-32	P1-00351	159.2	16.3	<1%	1.68%
	MS-25	P1-00362	135.3	9.1	8%	1.73%
	MS-31	P1-00389	187.4	32	<1%	0.75%
	MS-33	P1-00364	95.3	38.4	<1%	0.16%
	MS-34	P1-00344	179.8	52.1	<1%	0.54%
	MS-35	P1-00363	166.1	30.6	Tr	0.006%
	MS-36	P1-00375	226.6	14.9	<1%	0.3%
	MS-37	P1-00376	121.6	17.7	<1%	0.2%
	MS-38	P1-00377	123.2	65.5	<1%	0.4%

Refer to Tech Memo 8 for descriptions of Approach 1 and 2.

ND = not detected

Tr = trace

MF = mass fraction

-- = coarse fraction was not analyzed.

DRAFT RESULTS PENDING VALIDATION

Table 2-11. Asbestos Results for Forest Soil

Transect ID	StationID	IndexID	MASS (grams)		RESULTS	
			Fine Fraction	Coarse Fraction	MF _{LA%} fine	MF _{LA%} coarse
SL45 Approximate downwind from mine area.	SL45-01	P1-00202	107.9	4.8	<1%	Tr
	SL45-02	P1-00222	109.3	7.8	ND	Tr
	SL45-03	P1-00226	122.8	29.8	Tr	Tr
	SL45-04	P1-00143	119.6	12.8	ND	ND
	SL45-05	P1-00073	137.5	17.4	ND	ND
	SL45-06	P1-00085	127.3	17.5	ND	ND
	SL45-07	P1-00040	120.3	21.5	ND	ND
	SL45-08	P1-00083				
	SL45-09	P1-00081	113.9	48.3	ND	ND
	SL45-10	P1-00038	82.4	7.6	ND	ND
	SL45-11	P1-00036	58	0	ND	--
	SL45-12	P1-00059	118.6	11.3	ND	ND
	SL45-13	P1-00032	114.8	5.4	ND	ND
	SL45-14	P1-00034	158.4	6.8	ND	ND
	SL45-15	P1-00054	113.7	27.9	ND	ND
	SL45-16	P1-00052	86.6	3.3	ND	ND
SL15 30° counterclockwise from approximate primary downwind direction.	SL15-02	P1-00220	120.1	17.5	Tr	ND
	SL15-03	P1-00224	115.9	21.3	Tr	
	SL15-04	P1-00141	130.1	22.1	ND	ND
	SL15-05	P1-00100	79.5	0	ND	--
	SL15-06	P1-00122	97.2	4	ND	ND
	SL15-07	P1-00098	132.4	16.9	ND	ND
	SL15-08	P1-00096	153.8	5.1	ND	ND
	SL15-09	P1-00124				
	SL15-10	P1-00068				
	SL15-11	P1-00064	175.2	3.7	ND	ND
	SL15-12	P1-00046	66.6	51.9	ND	ND
	SL15-13	P1-00056	119	0	ND	--
	SL15-14	P1-00044	71.6	4.9	ND	ND
	SL15-15	P1-00062	97.8	16.5	ND	ND
	SL15-16	P1-00042	83.7	28.3	ND	ND
SL75 30° clockwise from approximate primary downwind direction.	SL75-02	P1-00228	77.9	0	Tr	--
	SL75-03	P1-00230	130	16.7	ND	ND
	SL75-04	P1-00164	136.6	44.7	Tr	ND
	SL75-05	P1-00108	132.7	19.3	ND	ND
	SL75-06	P1-00110	160	26.1	ND	ND
	SL75-07	P1-00168				
	SL75-08	P1-00170	126.8	16.2	ND	ND
	SL75-09	P1-00128	157.8	5.4	ND	ND
	SL75-13	P1-00093				
	SL75-14	P1-00066	111	17.2	ND	ND
	SL75-15	P1-00103	143.9	20.1	ND	ND
	SL75-16	P1-00130	177	20.9	ND	ND
SL195 Generally upwind of mine area/possibly downwind from Screening Plant.	SL195-02	P1-00204	137	3	ND	ND
	SL195-03	P1-00136	170	37	ND	ND
	SL195-04	P1-00134	90.3	33.7	ND	ND
	SL195-05	P1-00192	74.6	7.2	ND	ND
	SL195-06	P1-00115	102.1	18.4	ND	ND
	SL195-07	P1-00106	104.5	11.9	ND	Tr
	SL195-08	P1-00162	130.2	32.3	ND	ND
	SL195-10	P1-00172	99.1	0	ND	--
SL255 Approximate upwind direction from mine area.	SL195-11	P1-00112	90.6	4.8	ND	ND
	SL195-12	P1-00149	120.5	16.2	ND	ND
	SL255-02	P1-00214	113.6	38.6	ND	Tr
	SL255-03	P1-00212	117.6	18.6	ND	ND
	SL255-04	P1-00180	77.9	10.1	ND	ND
	SL255-05	P1-00177	152.9	19.5	ND	ND
SL135 Across-gradient from primary downwind direction.	SL255-06	P1-00174	150.1	80.5	ND	Tr
	SL135-01	P1-00140	274.4	12.3	6%	1.32%
	SL135-02	P1-00138	103.6	11.5	Tr	Tr
	SL135-03	P1-00166	159.3	30.6	ND	ND
	SL135-04	P1-00077	132.5	6.5	ND	ND
	SL135-05	P1-00087	120.9	65.4	ND	ND
	SL135-06	P1-00089	167.6	39	ND	ND
	SL135-07	P1-00080	61.5	7.7	ND	ND
SL315 Across-gradient from primary downwind direction.	SL135-08	P1-00160	115.5	30.2	ND	ND
	SL315-01	P1-00216	120.9	0	Tr	--
	SL315-02	P1-00218	111.9	2.9	ND	ND
	SL315-03	P1-00132	178.6	24.6	ND	ND
	SL315-04	P1-00152	197.8	16.8	ND	ND
	SL315-05	P1-00155	94.2	15.8	ND	ND
	SL315-06	P1-00145	176.5	12.7	ND	ND
	SL315-07	P1-00147	97.6	33	ND	ND
	SL315-08	P1-00158	89.3	10.3	ND	ND

Refer to Tech Memo 8 for descriptions of Approach 1 and 2.

ND = not detected

Tr = trace

MF = mass fraction

-- = coarse fraction was not analyzed.

TABLE 2-12. AMBIENT AIR FIELD SAMPLE RESULTS

Station ID	Round	Index ID	Sensitivity 1/cc	LA Count	Conc s/cc
A-1	1	P1-00005	5.6E-04	0	0.0E+00
	2	P1-00017	5.6E-04	0	0.0E+00
	3	P1-00243	4.5E-04	0	0.0E+00
	4	P1-00277	5.6E-04	0	0.0E+00
A-2	1	P1-00006	5.6E-04	0	0.0E+00
	2	P1-00018	5.6E-04	0	0.0E+00
	3	P1-00244	4.5E-04	0	0.0E+00
	4	P1-00278	5.6E-04	0	0.0E+00
A-3	1	P1-00010	5.6E-04	0	0.0E+00
	2	P1-00024	5.6E-04	0	0.0E+00
	3	P1-00250	4.5E-04	0	0.0E+00
	4	P1-00284	5.6E-04	0	0.0E+00
A-4	1	P1-00007	6.2E-04	0	0.0E+00
	2	P1-00020	5.6E-04	0	0.0E+00
	3	P1-00245	4.6E-04	0	0.0E+00
	4	P1-00279	5.6E-04	0	0.0E+00
A-5	1	P1-00008	6.2E-04	0	0.0E+00
	2	P1-00022	5.6E-04	0	0.0E+00
	3	P1-00247	4.5E-04	0	0.0E+00
	4	P1-00281	5.6E-04	0	0.0E+00
A-6	1	P1-00009	5.6E-04	0	0.0E+00
	2	P1-00023	5.6E-04	0	0.0E+00
	3	P1-00249	4.5E-04	0	0.0E+00
	4	P1-00283	5.6E-04	0	0.0E+00
A-7	1	P1-00001	5.6E-04	0	0.0E+00
	2	P1-00015	5.6E-04	0	0.0E+00
	3	P1-00241	4.5E-04	0	0.0E+00
	4	P1-00275	5.6E-04	0	0.0E+00
A-8	1	P1-00003	6.2E-04	0	0.0E+00
	2	P1-00016	8.0E-04	0	0.0E+00
	3	P1-00242	4.5E-04	0	0.0E+00
	4	P1-00276	5.6E-04	0	0.0E+00

Round 1: 10/2/2007 - 10/7/2007

Round 2: 10/7/2007 - 10/12/2007

Round 3: 10/12/2007 - 10/17/2007

Round 4: 10/17/2007 - 10/22/2007

Table 2-13. Analytical Methods for Surface Water

Category	Method	Analytes			
Metals	SW6020 & SW 6010B	Aluminum	Beryllium	Copper	Selenium
		Antimony	Cadmium	Lead	Silver
	SW7470A	Arsenic	Chromium	Manganese	Thallium
		Barium	Cobalt	Nickel	Vanadium
		Boron	Iron	Potassium	Zinc
		Calcium	Magnesium	Sodium	
		Mercury			
Pesticides	SW8081A	4,4'-DDD	beta-BHC	Endosulfan sulfate	Heptachlor
		4,4'-DDE	Chlordane	Endrin	Heptachlor epoxide
	SW8151A	4,4'-DDT	delta-BHC	Endrin aldehyde	Isodrin
		Aldrin	Dieldrin	Endrin ketone	Methoxychlor
		alpha-BHC	Endosulfan I	gamma-BHC (Lindane)	Toxaphene
		alpha-Chlordane	Endosulfan II	gamma-Chlordane	
		2,4,5-T	Dalapon	MCPA	
Organophosphorus Pesticides	8141A	2,4,5-TP (Silvex)	Dicamba	MCPP	
		2,4-D	Dichlorprop	Pentachlorophenol	
	8141A	Dichlorvos	Diazinon	Chlorpyrifos	Stirophos (Tetrachlorovinphos)
		Mevinphos	Disulfoton	Trichloronate	Bolstar (Sulprofos)
	8141A	Demeton-O,S	Dimethoate	Methyl Parathion	Fensulfothion
		Ethoprop (Prophos)	Ronnel	Mathion	EPN
		Phorate	Merphos	Tokuthion (Prothiofos)	Azinphos-methyl (Guthion)
		Sulfotep	Fenthion	Ethyl Parathion	Coumaphos
PCBs	SW8082	Aroclor 1016	Aroclor 1242	Aroclor 1260	
		Aroclor 1221	Aroclor 1248	Aroclor 1262	
		Aroclor 1232	Aroclor 1254	Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane	1,3-Dichlorobenzene	Chlorodibromomethane	Methyl isobutyl ketone
		1,1,2,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	Methyl tert-butyl ether (MTBE)
		1,1,2-Trichloro-1,2,2-trifluoroethane	1,4-Dioxane	Chloroform	Methylcyclohexane
		1,1,2-Trichloroethane	2-Hexanone	Chloromethane	Methylene chloride
		1,1-Dichloroethane	Acetone	cis-1,2-Dichloroethene	o-Xylene
		1,1-Dichloroethene	Benzene	cis-1,3-Dichloropropene	Styrene
		1,2,3-Trichlorobenzene	Bromochloromethane	Cyclohexane	Tetrachloroethene
		1,2,4-Trichlorobenzene	Bromodichloromethane	Dichlorodifluoromethane	Toluene
		1,2-Dibromo-3-chloropropane	Bromoform	Ethylbenzene	trans-1,2-Dichloroethene
		1,2-Dibromoethane	Bromomethane	Isopropylbenzene	trans-1,3-Dichloropropene
		1,2-Dichlorobenzene	Carbon disulfide	m+p-Xylenes	Trichloroethene
		1,2-Dichloroethane	Carbon tetrachloride	Methyl acetate	Trichlorofluoromethane
		1,2-Dichloropropane	Chlorobenzene	Methyl ethyl ketone	Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene	3,3'-Dichlorobenzidine	bis(-2-chloroethyl)Ether	Hexachlorocyclopentadiene
		2,3,4,6-Tetrachlorophenol	3-Nitroaniline	bis(2-chloroisopropyl)Ether	Hexachloroethane
		2,4,5-Trichlorophenol	4,6-Dinitro-2-methylphenol	bis(2-ethylhexyl)Phthalate	m+p-Cresols
		2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Butylbenzylphthalate	Nitrobenzene
		2,4-Dichlorophenol	4-Chloro-3-methylphenol	Caprolactam	n-Nitroso-di-n-propylamine
		2,4-Dimethylphenol	4-Chlorophenyl phenyl ether	Carbazole	n-Nitrosodiphenylamine
		2,4-Dinitrophenol	4-Nitroaniline	Dibenzofuran	o-Cresol
		2,4-Dinitrotoluene	4-Nitrophenol	Diethyl phthalate	p-Chloroaniline
		2,6-Dinitrotoluene	Acetophenone	Dimethyl phthalate	Pentachlorophenol
		2-Chloronaphthalene	Atrazine	Di-n-butyl phthalate	Phenol
		2-Chlorophenol	Benzaldehyde	Di-n-octyl phthalate	
		2-Nitroaniline	Biphenyl	Hexachlorobenzene	
		2-Nitrophenol	bis(-2-chloroethoxy)Methane	Hexachlorobutadiene	
PAHs	SW8270C	2-Methylnaphthalene	Benzo(a)pyrene	Dibenzo(a,h)anthracene	Naphthalene
		Acenaphthene	Benzo(b)fluoranthene	Fluoranthene	Phenanthrene
		Acenaphthylene	Benzo(g,h,i)perylene	Fluorene	Pyrene
		Anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	
		Benzo(a)anthracene	Chrysene	Isophorone	
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics	C9 to C18 Aliphatics		
	SW8015M	C19 to C36 Aliphatics	Total Extractable Hydrocarbons		
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics	Benzene	Methyl tert-butyl ether (MTBE)	
		C9 to C10 Aromatics	Ethylbenzene	Naphthalene	
	MA-VPH	C9 to C12 Aliphatics	Toluene	m+p-Xylenes	
		Total Purgeable Hydrocarbons	Xylenes, Total	o-Xylene	
Nitrogen cmpds	E350.1	Nitrogen, Ammonia as N			
	E351.2	Nitrogen, Kjeldahl, Total as N			
	E353.2	Nitrogen, Nitrate+Nitrite as N			
	E353.2	Nitrogen, Nitrite as N	Nitrogen, Nitrate as N		
Radionuclides	E900.0	Gross Alpha			
	E903.0	Radium 226			
	RA-05	Radium 228			
	A7500-RA	Radium 226 + Radium 228			
Anions	E300.0	Chloride	Fluoride	Sulfate	
	E365.1	Orthophosphate as P			
	Kelada mod	Cyanide, Total			
Water quality parameters	A2320 B	Alkalinity, Total as CaCO3			
		Bicarbonate as HCO3			
		Carbonate as CO3			
	A2540 C,D	Hardness as CaCO3			
		Solids, Total Dissolved TDS			
	A5310 C	Organic Carbon, Dissolved (DOC)			

Table 2-14. List of Surface Water Stations and Analyses

			Asbestos (L.A)	Cations		Pesticides			PCBs	VOCs	SVOCs	PAHs	Petroleum Hydrocarbons		Nitrogen Compunds				Radionuclides				Anions			Water quality parameters					
				TAL Metals	Hg								Extractable HC	Volatile HC	NH4	Total N	NO2+NO3	NO2	Gross α	Ra226	Ra228	Ra226+228	Cl, F, SO4	PO4	CN	HCO3,CO3	TDS	DOC			
Sample	Reach	Station	EPA 100.2	SW620	SW6010B	SW7470A	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E150.1	E151.2	E153.2	E153.2	E900.0	E903.0	RA-05	A7500-RA	E300.0	E165.1	Kelada	A3320 B	A340C,D	A3310 C	
1	Upper Rainy Creek	URC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
2		URC-2	X	X	X	X										X	X	X	X	X	X					X	X		X	X	X
3	Tailings impoundment	TP	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
4		TP-TOE1	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
5		TP-TOE2	X	X	X	X										X	X	X	X	X	X	X	X	X		X	X		X	X	X
6	Mill pond	MP	X	X	X	X									X	X				X					X	X		X	X	X	
7	Lower Rainy Creek	LRC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
8		LRC-2	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
9		LRC-3	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
10		LRC-4	X	X	X	X										X	X	X	X	X	X					X	X		X	X	X
11		LRC-5	X	X	X	X										X	X	X	X	X	X					X	X		X	X	X
12		LRC-6	X	X	X	X										X	X	X	X	X	X					X	X		X	X	
13	Fleetwood Creek	FC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
14		FC-Pond	X	X	X	X							X	X	X	X	X	X	X	X					X	X		X	X	X	
15		FC-2	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X	
16	Carney Creek	CC-1	X	X	X	X									X	X				X					X	X		X	X	X	
17		CC-2	X	X	X	X									X	X				X					X	X		X	X	X	
18	Seeps	CCS-1	X	X	X										X	X	X	X	X	X					X	X		X	X	X	
19		CCS-6	X	X	X	X									X	X				X					X	X		X	X	X	
20		CCS-8	X	X	X	X									X	X				X					X	X		X	X	X	
21		CCS-9	X	X	X	X									X	X				X					X	X		X	X	X	
22		CCS-11	X	X	X	X									X	X				X					X	X		X	X	X	
23		CCS-14	X	X	X	X							X	X	X	X				X					X	X		X	X	X	
24		CCS-16	X	X	X	X									X	X				X					X	X		X	X	X	

X= Sample analyzed

Table 2-15. Non-Asbestos Results for Surface Water

Category	Detected Analytes	Units	Detection Frequency (DF)	Mean Detection Limit (DL)	Concentration		Screening Benchmark	
					Mean ¹	Max	Aquatic Receptors	
Metals [†]	Barium	mg/L	24 / 24 100%	na	0.47	1.00	5	
	Calcium	mg/L	24 / 24 100%	na	82	131	--	
	Copper	mg/L	1 / 24 4%	0.002	0.0011	0.004	0.02	2
	Iron	mg/L	3 / 24 13%	0.03	0.071	1.34	--	
	Magnesium	mg/L	24 / 24 100%	na	24	49	82	
	Manganese	mg/L	5 / 24 21%	0.02	0.045	0.66	1.5	3
	Potassium	mg/L	24 / 24 100%	na	13	33	53	
	Sodium	mg/L	24 / 24 100%	na	8	15	680	
	Vanadium	mg/L	1 / 24 4%	0.01	0.0052	0.01	0.02	
Volatile Hydrocarbons	Benzene	ug/L	1 / 24 4%	0.5	0.27	0.65	130	
	C5 to C8 Aliphatics	ug/L	3 / 24 13%	20	13.6	62	--	
	TPH	ug/L	3 / 24 13%	20	13.0	53	--	
Extractable Hydrocarbons	TEH	mg/L	2 / 24 8%	0.30	0.17	0.47	--	
Nitrogen Compounds	Nitrate	mg/L	10 / 15 67%	0.01	0.1	1.2	--	
	Nitrite	mg/L	1 / 24 4%	0.01	0.0	0.01	--	
Radionuclides	Gross Alpha	pCi/L	2 / 2 100%	na	2.1	2.5	--	
Anions	Chloride	mg/L	22 / 24 92%	1	4.5	10	230	
	Fluoride	mg/L	24 / 24 100%	na	0.4	0.9	--	
	Sulfate	mg/L	24 / 24 100%	na	19.9	58	--	
	PO ₄	mg/L	24 / 24 100%	na	0.2	1.16	--	
Water Quality Parameters	Hardness as CaCO ₃	mg/L	20 / 20 100%	na	307	464	--	
	Carbonate as CO ₃	mg/L	2 / 24 8%	4	2.5	11	--	
	TDS	mg/L	24 / 24 100%	na	371	549	--	4
	TSS	mg/L	4 / 24 17%	10	7.8	36	--	
	DOC	mg/L	23 / 23 100%	na	4.1	15	--	

na = not applicable, all samples detected

TPH = Total Purgeable Hydrocarbons

TEH = Total Extractable Hydrocarbons

[†]Data presented in this table are based on the dissolved fraction for metals

¹ Mean calculated assuming 1/2 DL for NDs

² AWQC based on the measured hardness of 299 mg/L at the station where the maximum concentration was detected.

³ Mn ions are rarely found above 1 mg/L; reported tolerance ranges from 1.5 mg/L to over 1000 mg/L (USEPA 1987).

⁴ TDS toxicity is a function of the individual concentrations of common ions (K⁺, HCO₃⁻, Mg²⁺, Cl⁻, SO₄²⁻) (Mount et al. 199

Table 2-16. Summary of Water Quality Parameters by Sampling Location

Station ID	Date	Time	Temperature (°C)	pH	Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Oxidation/Reduction Potential (mV)
URC-1	10/14/2007	10:45	4.68	8.46	0.377	12.21	4.2	295
URC-2	10/14/2007	9:15	3.89	8.43	0.402	37.72	6.8	278
LRC-1	10/15/2007	13:45	8.93	8.73	0.52	12.1	3.6	262
LRC-2	10/15/2007	12:35	7.85	8.68	0.522	11.52	3.2	310
LRC-3	10/15/2007	11:45	6.18	8.71	0.573	9.69	4.5	297
LRC-4	10/15/2007	11:00	5.04	8.72	0.573	12.37	4.7	319
LRC-5	10/15/2007	10:30	4.79	8.83	0.57	13.34	3.7	332
LRC-6	10/15/2007	9:45	5.73	8.74	0.546	11.92	7.5	311
FC-1	10/13/2007	11:30	6.5	8.76	11.17	10.65	8.5	287
FC-2	10/13/2007	12:45	7.08	8.69	7.12	10.84	2.4	259
FC-Upper Pond	10/13/2007	11:15	9.34	8.8	0.295	11.7	37.2	263
TP	12/12/2007	15:20	1	8.14	0.508	12.74	10.3	342
TP-TOE1	10/16/2007	12:00	8.73	7.71	0.703	6.08	1.9	299
TP-TOE2	10/16/2007	12:45	9.04	7.96	0.648	10.89	25.1	294
MP	10/16/2007	13:30	8.73	8.05	0.526	9.94	60.5	312
CC-1	10/11/2007	12:15	7.01	7.94	0.693	9.32	23.1	297
CC-2	10/11/2007	11:00	7.81	6.67	0.715	9.06	2.1	337
CCS-1	10/12/2007	12:47	8.77	8.23	0.746	8.28	225	266
CCS-6	10/12/2007	9:30	5.73	7.89	0.767	7.2	5999	1.92
CCS-8	10/17/2007	11:45	7.27	8.2	0.75	8.84	2.5	292
CCS-9	10/16/2007	11:00	8.39	8.16	0.746	24.05	3.8	323
CCS-11	10/12/2007	15:30	8.78	8.09	0.654	11.51	12.7	1.06
CCS-14	10/13/2007	10:00	7.12	8.41	0.59	30.5	24.1	283
CCS-16	10/17/2007	10:15	7.44	8.04	0.904	30.79	6.4	188

Table 2-18. Analytical Methods for Sediment

Category	Method	Analytes			
Metals	SW6020 & SW6010B	Aluminum	Chromium	Selenium	
		Antimony	Cobalt	Silver	
		Arsenic	Copper	Thallium	
		Barium	Iron	Vanadium	
		Beryllium	Lead	Zinc	
		Boron	Manganese		
		Cadmium	Nickel		
	SW7471A	Mercury			
Cyanide	SW9012	Total cyanide			
Pesticides	SW8081A	4,4'-DDD	beta-BHC	Endosulfan sulfate	Heptachlor
		4,4'-DDE	Chlordane	Endrin	Heptachlor epoxide
		4,4'-DDT	delta-BHC	Endrin aldehyde	Isodrin
		Aldrin	Dieldrin	Endrin ketone	Methoxychlor
		alpha-BHC	Endosulfan I	gamma-BHC (Lindane)	Toxaphene
		alpha-Chlordane	Endosulfan II	gamma-Chlordane	
	SW8151A	2,4,5-T	Dalapon	MCPA	
		2,4,5-TP (Silvex)	Dicamba	MCPP	
		2,4-D	Dichlorprop	Pentachlorophenol	
Organophosphorus Pesticides	8141A	Dichlorvos	Diazinon	Chlorpyrifos	Stirophos (Tetrachlorovinphos)
		Mevinphos	Disulfoton	Trichloronate	Bolstar (Sulprofos)
		Demeton-O,S	Dimethoate	Methyl Parathion	Fensulfothion
		Ethoprop (Prophos)	Ronnel	Mathion	EPN
		Phorate	Merphos	Tokuthion (Prothiofos)	Azinphos-methyl (Guthion)
		Sulfotep	Fenthion	Ethyl Parathion	Coumaphos
PCBs	SW8082	Aroclor 1016	Aroclor 1242	Aroclor 1260	
		Aroclor 1221	Aroclor 1248	Aroclor 1262	
		Aroclor 1232	Aroclor 1254	Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane	1,3-Dichlorobenzene	Chlorodibromomethane	Methyl isobutyl ketone
		1,1,2,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	Methyl tert-butyl ether (MTBE)
		1,1,2-Trichloro-1,2,2-trifluoroethane	1,4-Dioxane	Chloroform	Methylcyclohexane
		1,1,2-Trichloroethane	2-Hexanone	Chloromethane	Methylene chloride
		1,1-Dichloroethane	Acetone	cis-1,2-Dichloroethene	o-Xylene
		1,1-Dichloroethene	Benzene	cis-1,3-Dichloropropene	Styrene
		1,2,3-Trichlorobenzene	Bromochloromethane	Cyclohexane	Tetrachloroethene
		1,2,4-Trichlorobenzene	Bromodichloromethane	Dichlorodifluoromethane	Toluene
		1,2-Dibromo-3-chloropropane	Bromoforn	Ethylbenzene	trans-1,2-Dichloroethene
		1,2-Dibromoethane	Bromomethane	Isopropylbenzene	trans-1,3-Dichloropropene
		1,2-Dichlorobenzene	Carbon disulfide	m+p-Xylenes	Trichloroethene
		1,2-Dichloroethane	Carbon tetrachloride	Methyl acetate	Trichlorofluoromethane
		1,2-Dichloropropane	Chlorobenzene	Methyl ethyl ketone	Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene	3,3'-Dichlorobenzidine	bis-(2-chloroethyl)Ether	Hexachlorocyclopentadiene
		2,3,4,6-Tetrachlorophenol	3-Nitroaniline	bis-(2-chloroisopropyl)Ether	Hexachloroethane
		2,4,5-Trichlorophenol	4,6-Dinitro-2-methylphenol	bis(2-ethylhexyl)Phthalate	m+p-Cresols
		2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Butylbenzylphthalate	Nitrobenzene
		2,4-Dichlorophenol	4-Chloro-3-methylphenol	Caprolactam	n-Nitroso-di-n-propylamine
		2,4-Dimethylphenol	4-Chlorophenyl phenyl ether	Carbazole	n-Nitrosodiphenylamine
		2,4-Dinitrophenol	4-Nitroaniline	Dibenzofuran	o-Cresol
		2,4-Dinitrotoluene	4-Nitrophenol	Diethyl phthalate	p-Chloroaniline
		2,6-Dinitrotoluene	Acetophenone	Dimethyl phthalate	Pentachlorophenol
		2-Chloronaphthalene	Atrazine	Di-n-butyl phthalate	Phenol
		2-Chlorophenol	Benzaldehyde	Di-n-octyl phthalate	
		2-Nitroaniline	Biphenyl	Hexachlorobenzene	
		2-Nitrophenol	bis-(2-chloroethoxy)Methane	Hexachlorobutadiene	
PAHs	SW8270C	2-Methylnaphthalene	Benzo(a)pyrene	Dibenzo(a,h)anthracene	Naphthalene
		Acenaphthene	Benzo(b)fluoranthene	Fluoranthene	Hexachloroethane
		Acenaphthylene	Benzo(g,h,i)perylene	Fluorene	Phenanthrene
		Anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	Pyrene
		Benzo(a)anthracene	Chrysene	Isophorone	
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics	C9 to C18 Aliphatics		
		C19 to C36 Aliphatics	Total Extractable Hydrocarbons		
	SW8015M	Total Extractable Hydrocarbons			
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics	Benzene	Methyl tert-butyl ether (MTBE)	
		C9 to C10 Aromatics	Ethylbenzene	Naphthalene	
		C9 to C12 Aliphatics	Toluene	m+p-Xylenes	
		Total Purgeable Hydrocarbons	Xylenes, Total	o-Xylene	
Anions	E300.0	Fluoride			
	E365.1	Total Phosphorus			
Sediment quality parameters	ASAM10-3.2	pH, sat. paste			
	SW3550A	Moisture			
	Leco	Carbon, Organic			

Table 2-19. List of Sediment Stations and Analyses

			Asbestos (LA)		Cations			Cyanide	Pesticides			PCBs	VOCs	SVOCs	PAHs	Petroleum Hydrocarbons			Anions		Sediment quality parameters		
					TAL Metals	Hg	Extractable HC									Volatile HC	Fluoride	Phosphorus	pH	Moisture	OC		
Sample	Reach	Station	PLM-VE	PLM-GRAY	SW6020	SW6010B	SW7471A	SW9012	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E300.0	E365.1	ASAM10-3.2	SW3550A	Leco
1	Upper Rainy Creek	URC-1	X		X	X	X								X	X	X	X	X	X	X	X	X
2		URC-2	X	X	X	X	X								X	X	X	X	X	X	X	X	X
3	Tailings impoundment	TP	X	X	X	X	X								X	X	X	X	X	X	X	X	X
4		TP-TOE1	X	X	X	X	X										X	X	X	X	X	X	X
5		TP-TOE2	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
6	Mill pond	MP	X		X	X	X								X	X	X	X	X	X	X	X	X
7	Lower Rainy Creek	LRC-1	X	X	X	X	X		X	X		X					X	X	X	X	X	X	X
8		LRC-2	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
9		LRC-3	X		X	X	X		X	X		X			X	X	X	X	X	X	X	X	X
10		LRC-4	X		X	X	X		X	X		X					X	X	X	X	X	X	X
11		LRC-5	X	X	X	X	X		X	X		X					X	X	X	X	X	X	X
12		LRC-6	X		X	X	X		X	X		X			X	X	X	X	X	X	X	X	X
13	Fleetwood Creek	FC-1	X	X	X	X	X										X	X	X	X	X	X	X
		FC-Pond	X		X	X	X								X	X	X	X	X	X	X	X	X
14		FC-2	X	X	X	X	X								X	X	X	X	X	X	X	X	X
16	Carney Creek	CC-1	X	X	X	X	X								X	X	X	X	X	X	X	X	X
17		CC-2	X	X	X	X	X										X	X	X	X	X	X	X
18	Seeps	CCS-1	X		X	X	X										X	X	X	X	X	X	X
19		CCS-6	X	X	X	X	X										X	X	X	X	X	X	X
20		CCS-8	X	X	X	X	X								X	X	X	X	X	X	X	X	X
21		CCS-9	X	X	X	X	X										X	X	X	X	X	X	X
22		CCS-11	X	X	X	X	X								X	X	X	X	X	X	X	X	X
23		CCS-14	X	X	X	X	X										X	X	X	X	X	X	X
24		CCS-16	X		X	X	X									X	X	X	X	X	X	X	X

X = Sample analyzed

Table 2-20. Non-Asbestos Results for Sediment

Category	Detected Analytes	Detection Frequency (DF)	Mean Detection Limit (DL) (mg/kg)	Concentration (mg/kg)		Screening Benchmarks		
				Mean ¹	Max	Aquatic Receptors		
						TEC	PEC	
Metals	Aluminum	24 / 24 100%	na	12,419	33,800	25,519	59,572	
	Arsenic	10 / 24 42%	2.00	2.1	7	10	33	
	Barium	24 / 24 100%	na	844	4,930	no benchmark		
	Chromium	24 / 24 100%	na	149	988	43	111	
	Cobalt	23 / 24 96%	5.00	18	75	no benchmark		
	Copper	24 / 24 100%	na	31	66	32	149	
	Iron	24 / 24 100%	na	21,817	54,600	188,400	247,600	
	Lead	23 / 24 96%	5.00	27	100	36	128	
	Manganese	24 / 24 100%	na	1,240	12,700	631	1,184	
	Mercury	2 / 24 8%	0.10	0.1	0.1	0.2	1	
	Nickel	23 / 24 96%	5.00	37	226	23	49	
	Selenium	4 / 24 17%	0.50	0.4	1.4	no benchmark		
	Thallium	3 / 24 13%	0.60	0.5	4.3	no benchmark		
	Vanadium	24 / 24 100%	na	45	105	no benchmark		
	Zinc	24 / 24 100%	na	27	54	121	459	
PAH	Pyrene	1 / 14 7%	0.87	0.4	1.2	0.2	2	
VOC	Methyl acetate	2 / 2 100%	na	0.3	0.4	no benchmark		
Extractable Hydrocarbons	C11 to C22 Aromatics	4 / 12 33%	24.41	63	436	no benchmark		
	C19 to C36 Aliphatics	4 / 12 33%	25.63	71	350	no benchmark		
	C9 to C18 Aliphatics	2 / 12 17%	26.40	28	162	no benchmark		
	TEH (MA-EPH)	4 / 12 33%	25.13	188	1,240	no benchmark		
	TEH (SW8015M)	23 / 24 96%	9.80	176	928	no benchmark		
Volatile Hydrocarbons	C9 to C10 Aromatics	1 / 24 4%	3.86	2.3	10	no benchmark		
	C9 to C12 Aliphatics	1 / 24 4%	3.95	2.0	10	no benchmark		
	TPH	3 / 24 13%	3.65	2.9	17	no benchmark		
Anions	Fluoride ²	5 / 24 21%	1.0	0.875	4.1	no benchmark		
	Total phosphorus ²	24 / 24 100%	na	2,564	10,200	no benchmark		
Sediment Quality Parameters	pH, sat. paste	24 / 24 100%	na	7.2	8	--	--	--
	Moisture	24 / 24 100%	na	39.9	86	--	--	--
	Carbon, Organic	24 / 24 100%	na	2.5	15	--	--	--

na = not applicable, all samples detected

TEH = Total Extractable Hydrocarbons

TPH = Total Purgeable Hydrocarbons

TEC = Threshold Effect Concentrations

PEC = Probable Effect Concentrations

¹ Mean calculated assuming 1/2 DL for NDs² Data not yet validated

Table 2-21. Analytical Methods for Mine Waste & On-site Soils

Category	Method	Analytes			
Metals	SW6020 & SW6010B	Aluminum Antimony Arsenic Barium Beryllium Boron Cadmium	Chromium Cobalt Copper Iron Lead Manganese Nickel	Selenium Silver Thallium Vanadium Zinc	
	SW7471A	Mercury			
Cyanide	SW9012	Total cyanide			
Pesticides	SW8081A	4,4'-DDD 4,4'-DDE 4,4'-DDT Aldrin alpha-BHC alpha-Chlordane	beta-BHC Chlordane delta-BHC Dieldrin Endosulfan I Endosulfan II	Endosulfan sulfate Endrin Endrin aldehyde Endrin ketone gamma-BHC (Lindane) gamma-Chlordane	Heptachlor Heptachlor epoxide Isodrin Methoxychlor Toxaphene
	SW8151A	2,4,5-T 2,4,5-TP (Silvex) 2,4-D	Dalapon Dicamba Dichlorprop	MCPA MCPP Pentachlorophenol	
Organophosphorus Pesticides	8141A	Dichlorvos Mevinphos Demeton-O,S Ethoprop (Prophos) Phorate Sulfotep	Diazinon Disulfoton Dimethoate Ronnol Merphos Fenthion	Chlorpyrifos Trichloronate Methyl Parathion Mathion Tokuthion (Prothiofos) Ethyl Parathion	Stirophos (Tetrachlorovinphos) Bolstar (Sulprofos) Fensulfothion EPN Azinphos-methyl (Guthion) Coumaphos
PCBs	SW8082	Aroclor 1016 Aroclor 1221 Aroclor 1232	Aroclor 1242 Aroclor 1248 Aroclor 1254	Aroclor 1260 Aroclor 1262 Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane 1,1,2,2-Tetrachloroethane 1,1,2-Trichloro-1,2,2-trifluoroethane 1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethene 1,2,3-Trichlorobenzene 1,2,4-Trichlorobenzene 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane	1,3-Dichlorobenzene 1,4-Dichlorobenzene 1,4-Dioxane 2-Hexanone Acetone Benzene Bromochloromethane Bromodichloromethane Bromoform Bromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene	Chlorodibromomethane Chloroethane Chloroform Chloromethane cis-1,2-Dichloroethene cis-1,3-Dichloropropene Cyclohexane Dichlorodifluoromethane Ethylbenzene Isopropylbenzene m+p-Xylenes Methyl acetate Methyl ethyl ketone	Methyl isobutyl ketone Methyl tert-butyl ether (MTBE) Methylcyclohexane Methylene chloride o-Xylene Styrene Tetrachloroethene Toluene trans-1,2-Dichloroethene trans-1,3-Dichloropropene Trichloroethene Trichlorofluoromethane Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene 2,3,4,6-Tetrachlorophenol 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol 2,4-Dichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,4-Dinitrotoluene 2,6-Dinitrotoluene 2-Chloronaphthalene 2-Chlorophenol 2-Nitroaniline 2-Nitrophenol	3,3'-Dichlorobenzidine 3-Nitroaniline 4,6-Dinitro-2-methylphenol 4-Bromophenyl phenyl ether 4-Chloro-3-methylphenol 4-Chlorophenyl phenyl ether 4-Nitroaniline 4-Nitrophenol Acetophenone Atrazine Benzaldehyde Biphenyl bis-(2-chloroethoxy)Methane	bis-(2-chloroethyl)Ether bis-(2-chloroisopropyl)Ether bis(2-ethylhexyl)Phthalate Butylbenzylphthalate Caprolactam Carbazole Dibenzofuran Diethyl phthalate Dimethyl phthalate Di-n-butyl phthalate Di-n-octyl phthalate Hexachlorobenzene Hexachlorobutadiene	Hexachlorocyclopentadiene Hexachloroethane m+p-Cresols Nitrobenzene n-Nitroso-di-n-propylamine n-Nitrosodiphenylamine o-Cresol p-Chloroaniline Pentachlorophenol Phenol
PAHs	SW8270C	2-Methylnaphthalene Acenaphthene Acenaphthylene Anthracene Benzo(a)anthracene	Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene	Dibenzo(a,h)anthracene Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene Isophorone	Naphthalene Phenanthrene Pyrene
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics C19 to C36 Aliphatics	C9 to C18 Aliphatics Total Extractable Hydrocarbons		
	SW8015M	Total Extractable Hydrocarbons			
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics C9 to C10 Aromatics C9 to C12 Aliphatics Total Purgeable Hydrocarbons	Benzene Ethylbenzene Toluene Xylenes, Total	Methyl tert-butyl ether (MTBE) Naphthalene m+p-Xylenes o-Xylene	
Anions	E300.0 E365.1	Fluoride Total Phosphorus			
Sediment quality parameters	ASAM10-3.2 SW3550A Leco	pH, sat. paste Moisture Carbon, Organic			

Table 2-22. List of Mine Waste and Soil Stations and Analyses

			Asbestos (LA)	Cations			Total Cyanide	Pesticides			PCBs	VOCs	SVOCs	PAHs	Petroleum Hydrocarbons			Anions		Sediment quality parameters			
				TAL Metals		Hg													Extractable HC	Volatile HC	Fluoride	Phosphorus	pH
Sample	Reach	Station	PLM-VE	SW6020	SW6010B	SW7471A	SW9012	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-FPH	SW8015M	MA-VPH	F300.0	F165.1	ASAM10-12	SW1550A	Leco	
1	Road	MS-1	X	X	X	X					X			X	X	X	X	X	X	X	X	X	
2		MS-2	X	X	X	X					X			X	X	X	X	X	X	X	X	X	
3		MS-3	X	X	X	X						X			X	X	X	X	X	X	X	X	X
4	Tailings Impoundment	MS-4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5		MS-5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Coarse Tailings	MS-6	X	X	X	X										X	X	X	X	X	X	X	X
7		MS-7	X	X	X	X										X	X	X	X	X	X	X	X
8		MS-8	X	X	X	X										X	X	X	X	X	X	X	X
9		MS-9	X	X	X	X											X	X	X	X	X	X	X
10	Cover Material	MS-10	X	X	X	X										X	X	X	X	X	X	X	X
11		MS-11	X	X	X	X											X	X	X	X	X	X	X
12		MS-12	X	X	X	X											X	X	X	X	X	X	X
13		MS-13	X	X	X	X											X	X	X	X	X	X	X
14		MS-21	X	X	X	X											X	X	X	X	X	X	X
15		MS-22	X	X	X	X												X	X	X	X	X	X
16		MS-23	X	X	X	X												X	X	X	X	X	X
17		MS-24	X	X	X	X												X	X	X	X	X	X
18	Waste Rock	MS-14	X	X	X	X											X	X	X	X	X	X	X
19		MS-15	X	X	X	X											X	X	X	X	X	X	X
20		MS-16	X	X	X	X											X	X	X	X	X	X	X
21		MS-17	X	X	X	X												X	X	X	X	X	X
22		MS-18	X	X	X	X												X	X	X	X	X	X
23		MS-19	X	X	X	X												X	X	X	X	X	X
24		MS-20	X	X	X	X									X	X		X	X	X	X	X	X
25		MS-26	X	X	X	X												X	X	X	X	X	X
26		MS-27	X	X	X	X												X	X	X	X	X	X
27		MS-28	X	X	X	X												X	X	X	X	X	X
28		MS-29	X	X	X	X												X	X	X	X	X	X
29		MS-30	X	X	X	X												X	X	X	X	X	X
30		MS-32	X	X	X	X												X	X	X	X	X	X
31	Outcrop	MS-25	X	X	X	X												X	X	X	X	X	X
32		MS-31	X	X	X	X												X	X	X	X	X	X
33		MS-33	X	X	X	X												X	X	X	X	X	X
34		MS-34	X	X	X	X												X	X	X	X	X	X
35		MS-35	X	X	X	X												X	X	X	X	X	X
36		MS-36	X	X	X	X												X	X	X	X	X	X
37		MS-37	X	X	X	X												X	X	X	X	X	X
38		MS-38	X	X	X	X												X	X	X	X	X	X

x = Sample

Table 2-23. Non-Asbestos Results for Mine Waste and Soil

Category	Detected Analytes	Detection Frequency (DF)	Mean Detection Limit (DL)	Concentration (mg/kg)		Screening Benchmarks (mg/kg)					
				Mean ¹	Max	Plants		Soil Invertebrates		Wildlife ²	
Metals	Aluminum	38 / 38 100%	na	17,874	50,900	pH-dep	3	pH-dep		pH-dep	3
	Antimony	1 / 38 3%	0.30	0.15	0.30	--		78		0.27	
	Arsenic	4 / 38 11%	2.00	1.16	3.00	18		--		43	
	Barium	38 / 38 100%	na	917	3,200	--		330		2,000	
	Chromium	38 / 38 100%	na	218	881	--		--		26	
	Cobalt	38 / 38 100%	na	27	63	13		--		120	
	Copper	37 / 38 97%	5.00	31	109	70		80		28	
	Iron	38 / 38 100%	na	24,905	51,900	pH-dep	4	pH-dep	4	pH-dep	4
	Lead	36 / 38 95%	5.00	19	50	120		1,700		11	
	Manganese	38 / 38 100%	na	357	808	220		450		4,300	
	Mercury	1 / 38 3%	0.10	0.06	0.30	--		--		0.161	
	Nickel	38 / 38 100%	na	57	135	38		280		130	
	Thallium	3 / 38 8%	0.60	0.34	0.90	--		--		--	
	Vanadium	38 / 38 100%	na	39	114	2		--		7.8	
PAHs	Zinc	38 / 38 100%	na	27	70	160		120		46	
	Benzo(a)anthracene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
	Benzo(a)pyrene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(b)fluoranthene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(g,h,i)perylene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(k)fluoranthene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Chrysene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
	Indeno(1,2,3-cd)pyrene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Pyrene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
Pesticide	Total HMW-PAHs			1.02	1.68	--		18		100	
	Pentachlorophenol	1 / 4 25%	0.31	0.13	0.25	5		31		2	
VOC	Methyl acetate	2 / 2 100%	na	1.13	1.7	--		--		--	
Extractable Hydrocarbons	C11 to C22 Aromatics	5 / 6 83%	13	33	78	--		--		--	
	C19 to C36 Aliphatics	6 / 6 100%	na	80	154	--		--		--	
	C9 to C18 Aliphatics	2 / 6 33%	11	17	53	--		--		--	
	TEH (MA-EPH)	6 / 6 100%	na	173	365	--		--		--	
	TEH (SW8015M)	22 / 30 73%	10.43	61.22	474	--		--		--	
Volatile Hydrocarbons	Toluene (MA-VPH)	1 / 30 3%	0.04	0.02	0.071	200		--		26	
	C5 to C8 Aliphatics	1 / 30 3%	1.66	0.85	1.4	--		--		--	
	C9 to C10 Aromatics	1 / 30 3%	1.66	1.33	16	--		--		--	
	Total Purgeable Hydrocarbons	3 / 30 10%	1.66	1.53	17	--		--		--	
Anions	Fluoride ⁶	2 / 38 5%	1.0	0.73	5	--		--		--	
	Total Phosphorus ⁶	38 / 38 100%	na	2,733	11,700	--		--		--	
Soil Quality Parameters	Carbon, Organic	38 / 38 100%	na	0.59	3	na		--		na	
	Moisture	38 / 38 100%	na	8.70	33	na		--		na	
	pH, sat. paste	38 / 38 100%	na	7.73	8.5	na		--		na	

na = not applicable

-- = not available

¹ Mean calculated assuming 1/2 DL for NDs² From Attachment C³ Aluminum is considered to be a contaminant of potential concern under conditions where soil pH is less than 5.5. Minimum reported soil pH for the mine waste samples was 6.3.⁴ A numeric Eco-SSL for iron was not derived. The potential toxicity of iron in soils is dependant on soil pH and Eh.⁵ Based on the Montana Numerical Water Quality Standards (DEQ-7) Tier 1 Surface Soil RBSLs (mg/kg) < 10 feet to groundwater.⁶ Data not yet validated.

TABLE 6-1 Histological Lesions in Fish Exposed to Asbestos

Reference	Species	Asbestos type	Exposure	Response Site	Observed Pathology	Gross Adverse Effect
Belanger et al. 1986	Coho Salmon	Chrysotile	5E+06 fibers/L	Lateral Line	Distortion, erosion, tumorous swelling and coelomic distention	Adverse rheotactic behavior (fish could not swim)
	Japanese Medaka	Chrysotile	1E+06 fibers/L	Epidermis	Increased thickening	Decreased growth, increased mortality
Yasutake 1982,1983	Multiple species	Chrysotile	1E+06 fibers/L	Gill	Lamella aneurysm, epithelial hypertrophy, hyperplasia, sloughing, degeneration, necrosis	No data
		Amosite	1E+09 fibers/ L	Epidermis	Sloughing, reduction in mucus cells	
				Kidney	Amorphous foreign bodies, extensive intracytoplasmic ceroid-like material in epithelial cells of renal tubules	
				Muscle	Fiber degeneration	
Woodhead et al. 1983	Amazon molly	Chrysotile	1mg/L	Heart	Vacuolation and necrosis of the sarcoplasm of the bulbus arteriosus	None
				Kidneys, gills	Lesions	None

Table 6-2 Wildlife Exposed Receptor Groups

Table 6-2 Wildlife Exposed Receptor Groups		
Exposed Receptor Group	Description of Exposed Group	Species in Group
Mammalian	Ground Invertivore	Dusky or Montane Shrew (<i>Sorex monticolus</i>) Masked Shrew (<i>Sorex cinereus</i>) Pygmy Shrew (<i>Sorex hoyi</i>) Vagrant Shrew (<i>Sorex vagrans</i>)
	Arboreal Invertivore	Northern Flying Squirrel (<i>Glaucomys sabrinus</i>) Red-tailed Chipmunk (<i>Tamias ruficaudus</i>)
	Ground Herbivore/ Omnivore	Bushy-tailed Woodrat (<i>Neotoma cinerea</i>) Columbian Ground Squirrel (<i>Spermophilus columbianus</i>) Deer Mouse (<i>Peromyscus maniculatus</i>) Golden-mantled Ground Squirrel (<i>Spermophilus lateralis</i>) Heather Vole (<i>Phenacomys intermedius</i>) Hoary Marmot (<i>Marmota caligata</i>) Long-tailed Vole (<i>Microtus longicaudus</i>) Mountain Cottontail (<i>Sylvilagus nuttallii</i>) Northern Pocket Gopher (<i>Thomomys talpoides</i>) Pika (<i>Ochotona princeps</i>) Red Squirrel (<i>Tamiasciurus hudsonicus</i>) Southern Red-backed Vole (<i>Clethrionomys gapperi</i>) Snowshoe Hare (<i>Lepus americanus</i>) Yellow-bellied Marmot (<i>Marmota flaviventris</i>) Yellow pine chipmunk (<i>Tamias amoenus</i>) Western Jumping Mouse (<i>Zapus princeps</i>)
	Carnivore	Marten (<i>Martes americana</i>) North American Wolverine (<i>Gulo gulo luscus</i>)
	Aquatic Invertivore/ Omnivore	Muskrat (<i>Ondatra zibethicus</i>) Water Shrew (<i>Sorex palustris</i>) Water Vole (<i>Microtus richardsoni</i>)
	Piscivore	Mink (<i>Mustela vison</i>).
Avian	Ground Invertivore	American robin (<i>Turdus migratorius</i>) Common Yellowthroat (<i>Geothlypis trichas</i>) Flammulated Owl (<i>Otus flammeolus</i>) House Wren (<i>Troglodytes aedon</i>) Killdeer (<i>Charadrius vociferus</i>) Nashville Warbler (<i>Vermivora ruficapilla</i>) Northern Flicker (<i>Colaptes auratus</i>) Rock Wren (<i>Salpinctes obsoletus</i>) Spotted Towhee (<i>Pipilo maculatus</i>) Townsend's Solitaire (<i>Myadestes townsendi</i>) Warbling Vireo (<i>Vireo gilvus</i>) Winter Wren (<i>Troglodytes troglodytes</i>) Western Bluebird (<i>Sialia mexicana</i>)
	Arboreal Invertivore	American Redstart (<i>Setophaga ruticilla</i>) American Three-toed Woodpecker (<i>Picoides dorsalis</i>) Black-backed Woodpecker (<i>Picoides arcticus</i>)

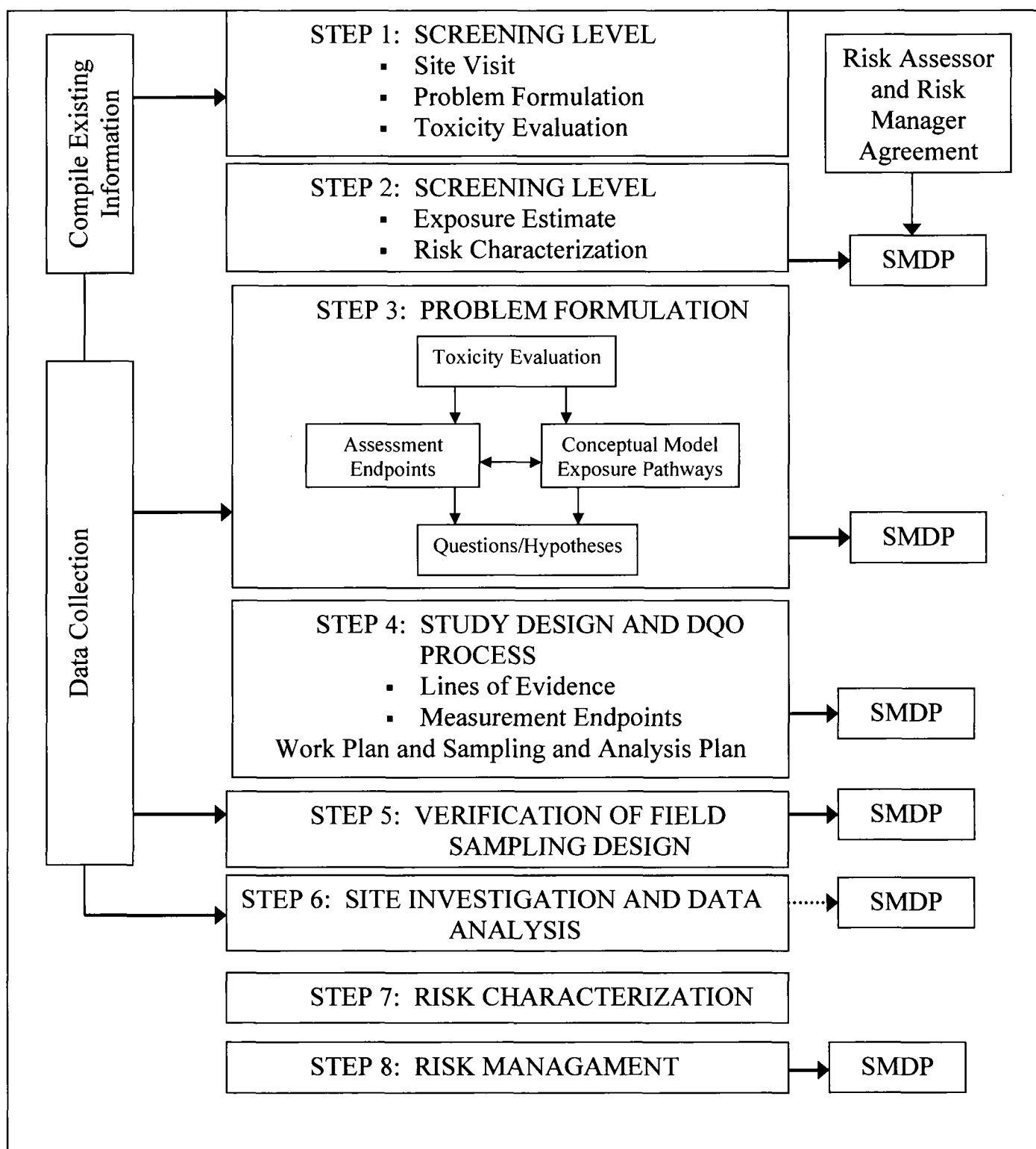
Table 6-2 Wildlife Exposed Receptor Groups

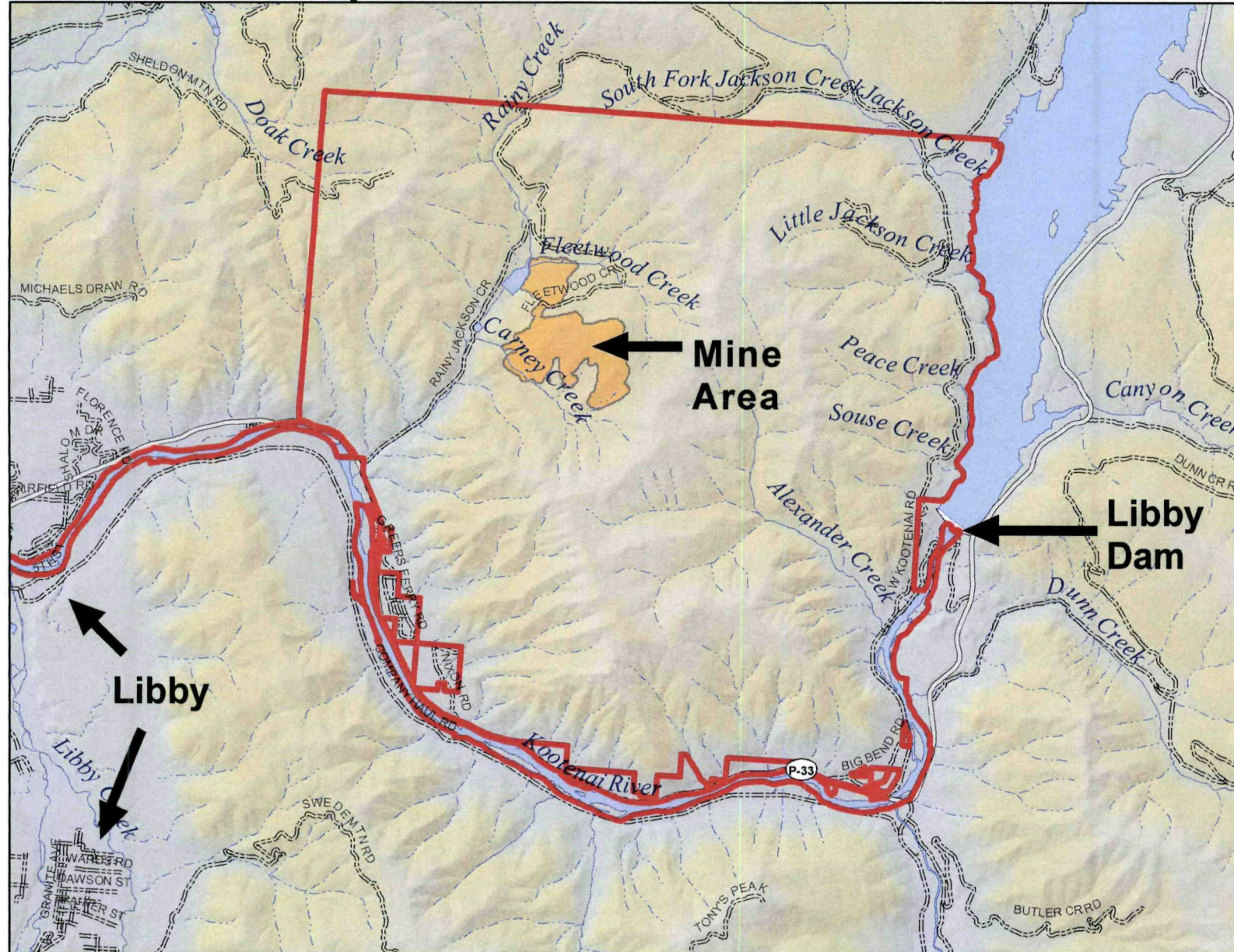
Exposed Receptor Group	Description of Exposed Group	Species in Group
		Black-capped Chickadee (<i>Poecile atricapillus</i>) Brown Creeper (<i>Certhia Americana</i>) Chestnut-backed Chickadee (<i>Poecile rufescens</i>) Downy Woodpecker (<i>Picoides pubescens</i>) Golden-crowned Kinglet (<i>Regulus satrapa</i>) Orange-crowned Warbler (<i>Vermivora celata</i>) Pileated Woodpecker (<i>Dryocopus pileatus</i>) Pygmy Nuthatch (<i>Sitta pygmaea</i>) Red-breasted Nuthatch (<i>Sitta canadensis</i>) Ruby-crowned Kinglet (<i>Regulus calendula</i>) Townsend's Warbler (<i>Dendroica townsendi</i>)
Ground Herbivore	Avian species that feed primarily on plant material and forage on the ground.	Chipping Sparrow (<i>Spizella passerina</i>) Common Redpoll (<i>Carduelis flammea</i>) Pine Siskin (<i>Carduelis pinus</i>) Spruce Grouse (<i>Falcipennis canadensis</i>) Mourning Dove (<i>Zenaida macroura</i>) Ruffed Grouse (<i>Bonasa umbellus</i>)
Carnivore	Avian species that feed on other birds and small mammals.	American Kestrel (<i>Falco sparverius</i>) Barred Owl (<i>Strix varia</i>) Boreal Owl (<i>Aegolius funereus</i>) Northern Goshawk (<i>Accipiter gentilis</i>) Northern Pygmy-owl (<i>Glaucidium gnoma</i>)
Aquatic Invertivore	Avian species that forage in along streams and ponds probing into sediments.	American Dipper (<i>Cinclus mexicanus</i>) Bank Swallow (<i>Riparia riparia</i>) Bufflehead (<i>Bucephala albeola</i>) Marsh Wren (<i>Cistothorus palustris</i>) Rufous Hummingbird (<i>Selasphorus rufus</i>) Spotted Sandpiper (<i>Actitis macularius</i>)
Aquatic Herbivore/ Omnivore	Avian species that feed on aquatic vegetation and sometimes aquatic invertebrates	American Coot (<i>Fulica americana</i>) American Wigeon (<i>Anas americana</i>) Blue-winged Teal (<i>Anas discors</i>) Green-winged Teal (<i>Anas crecca</i>) Mallard (<i>Anas platyrhynchos</i>)
Piscivore	Represents piscivorous avian species that feed primarily on fish and some invertebrates.	Belted kingfisher (<i>Ceryle alcyon</i>) Common Merganser (<i>Mergus merganser</i>) Great Blue Heron (<i>Ardea herodias</i>) Marsh Wren (<i>Cistothorus palustris</i>)

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FIGURES

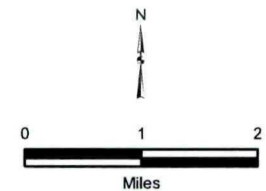
Figure 1-1
Eight Step Process Recommended in Ecological Risk Assessment
Guidance for Superfund (ERAGs) (USEPA, 1997)





Legend

- Mined Area
- Open Water
- County Road
- Primary Road
- Perennial Stream
- Intermittent Stream
- Preliminary Operable Unit 3 Boundary

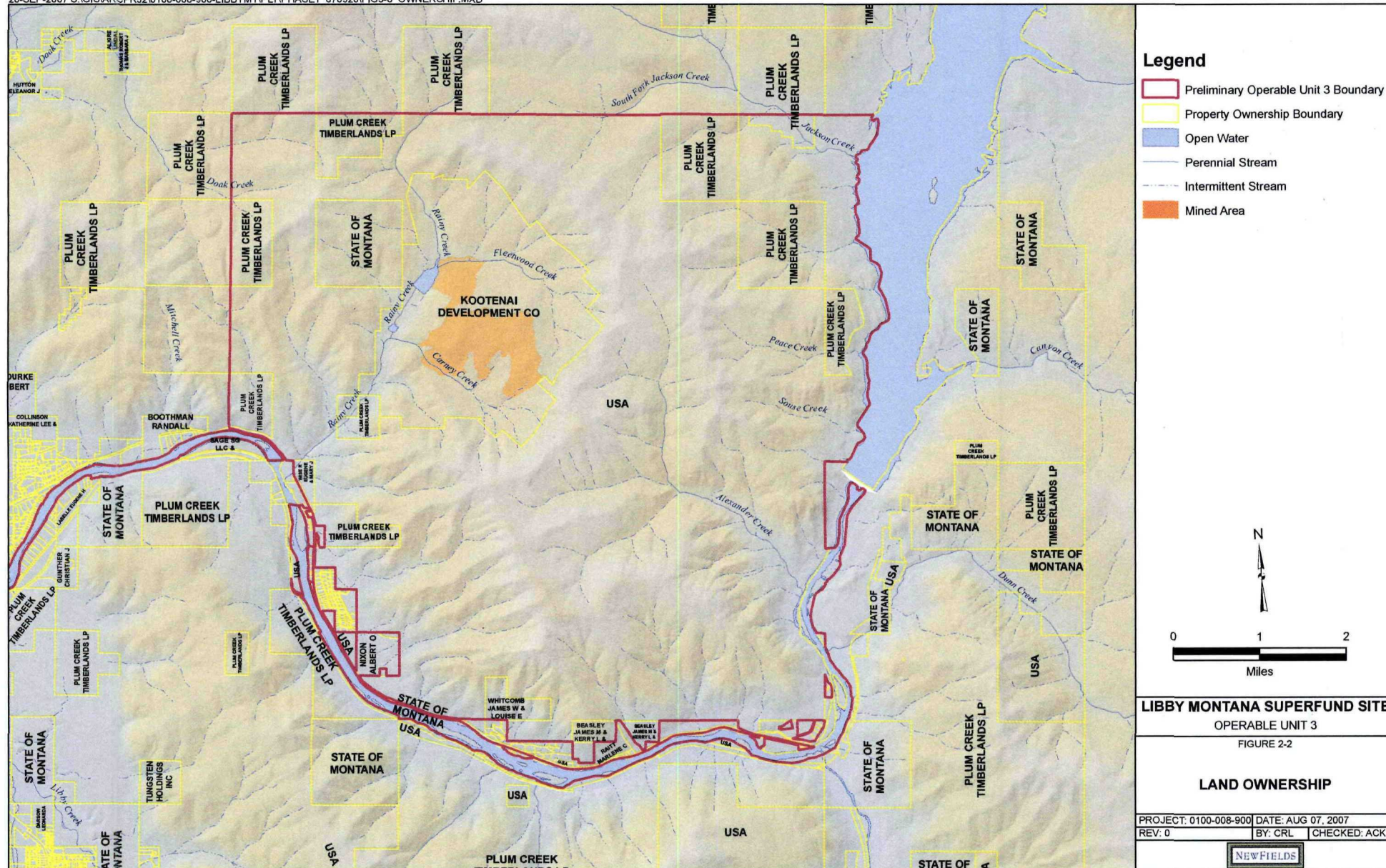


Libby Montana Superfund Site
Operable Unit 3

FIGURE 2-1

Operable Unit 3

PROJECT: 0100-008-900	DATE: AUG 02, 2007
REV: 0	BY: CHECKED: ACK

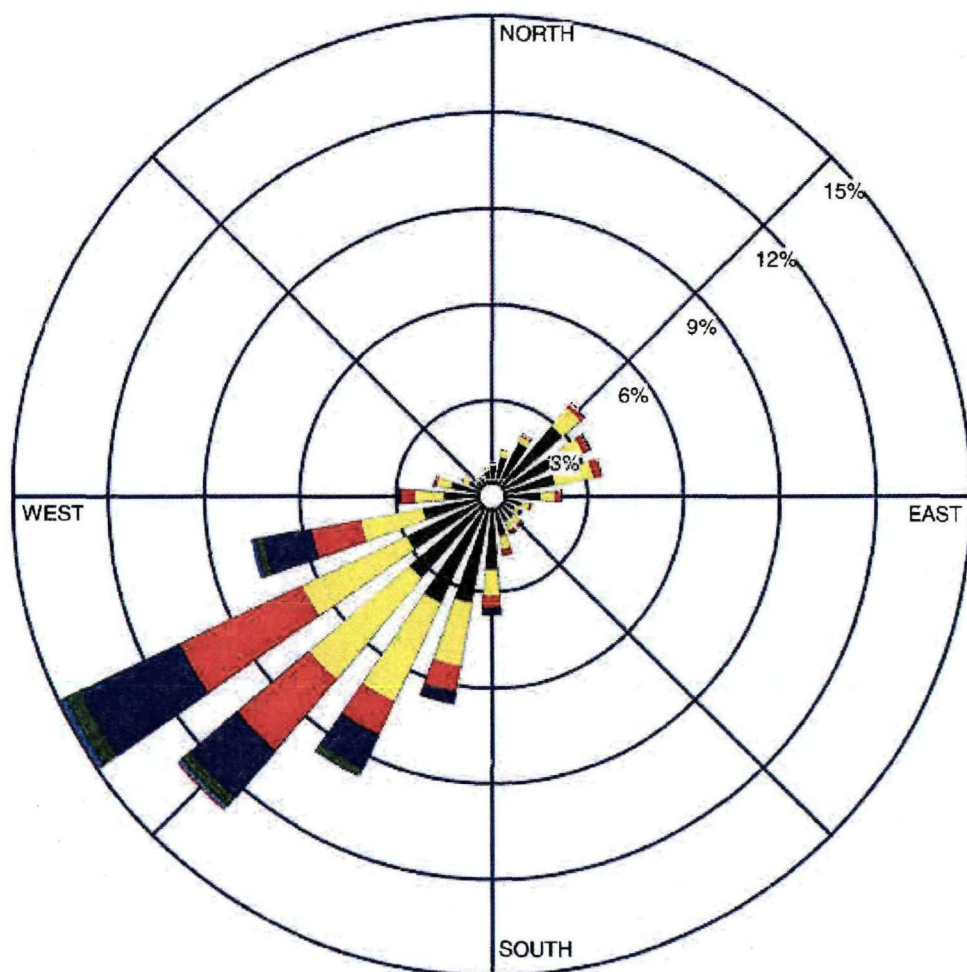


WIND ROSE PLOT:

**Zonolite Mountain
Libby, Montana**

DISPLAY:

**Wind Speed
Direction (blowing from)**



WIND SPEED
(Knots)



Calms: 11.89%

Figure 2-3

COMMENTS:

**Cumulative Data
December 14, 2006 to
December 31, 2007**

**Missing data from
November 17 2007 to
December 14 2007**

DATA PERIOD:

**2006-2007
Jan 1 - Dec 31
00:00 - 23:00**

CALM WINDS:

11.89%

AVG. WIND SPEED:

5.03 Knots

COMPANY NAME:

W.R. Grace

MODELER:

MWH

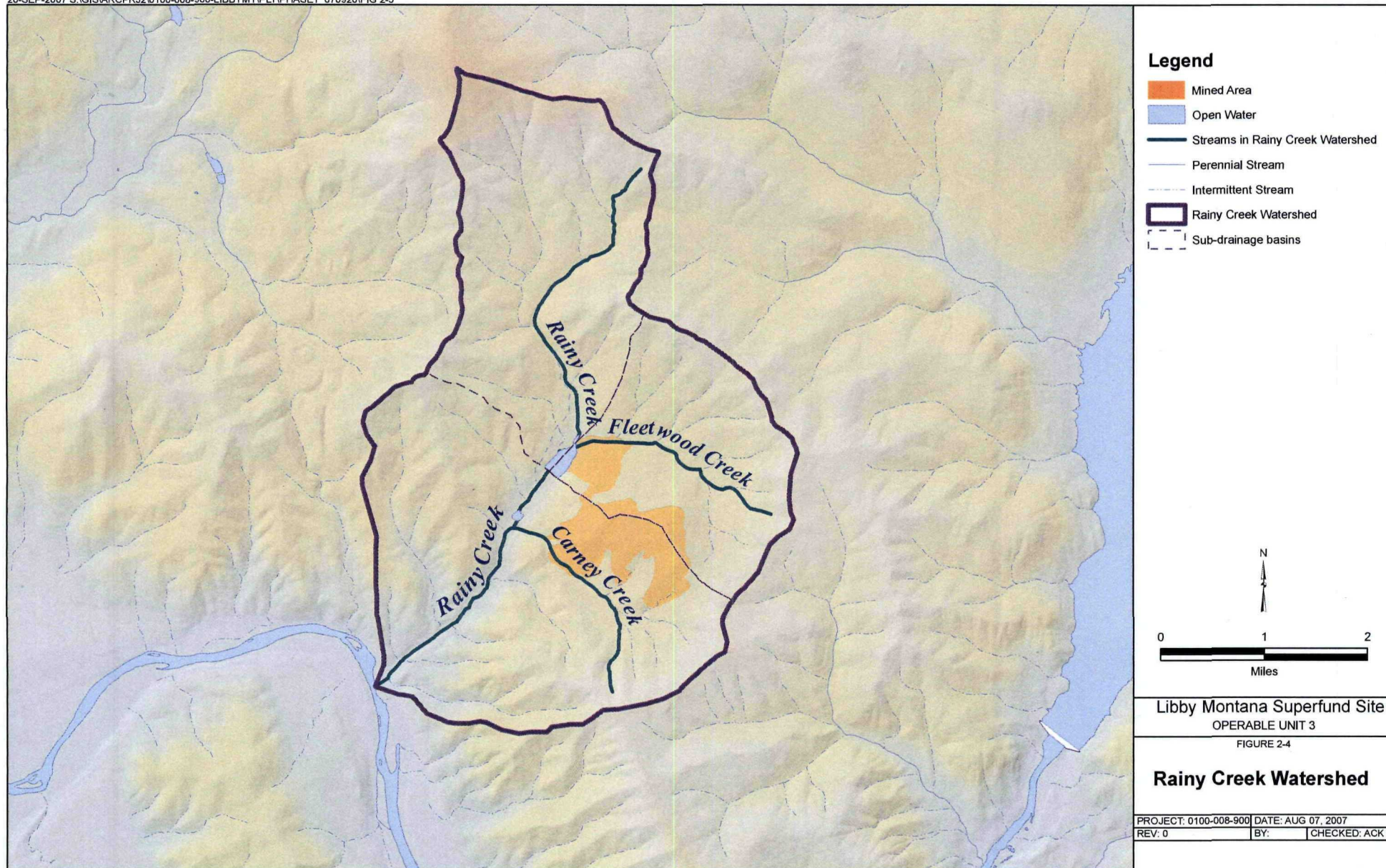
TOTAL COUNT:

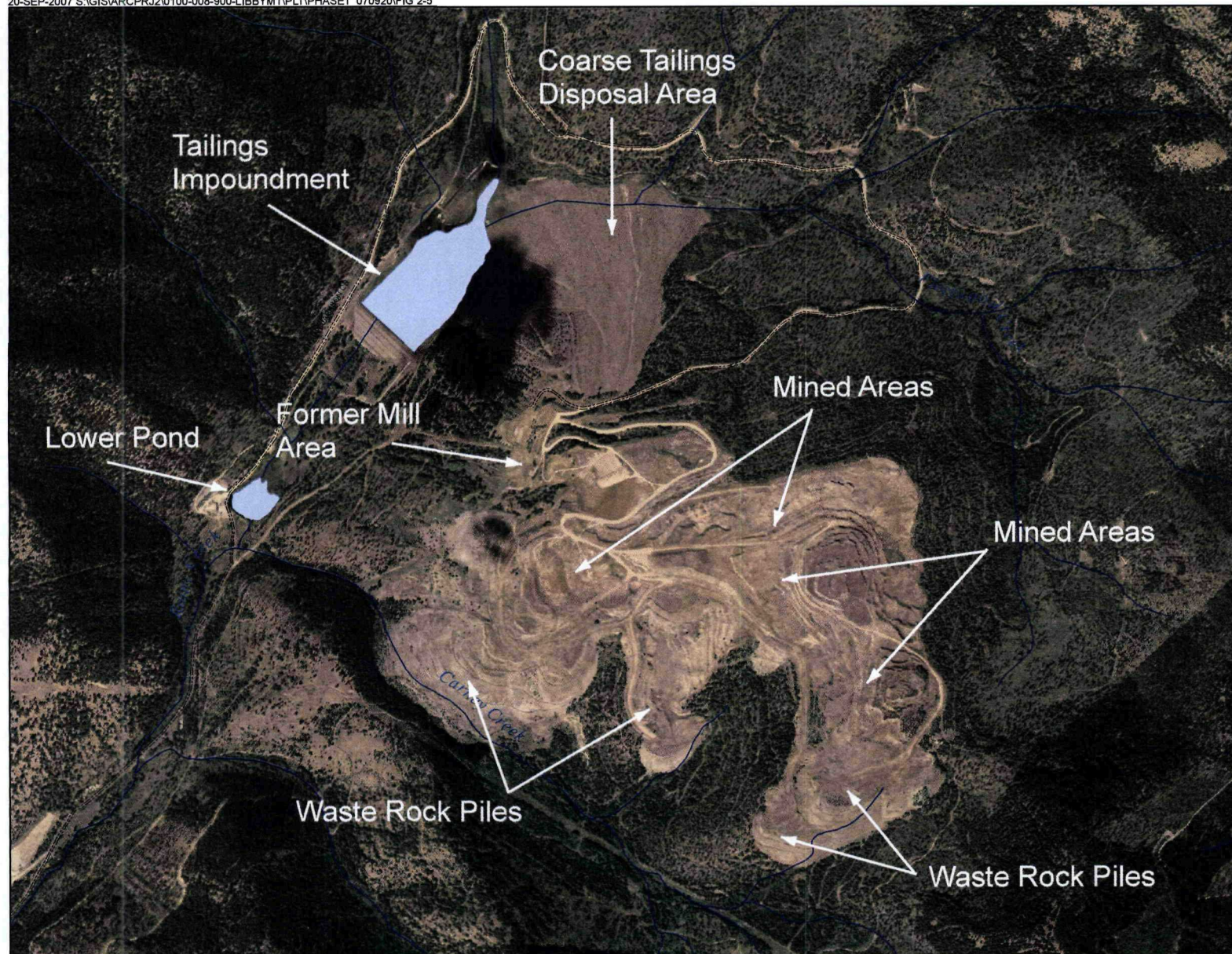
8534 hrs.

DATE:





1/18/2008

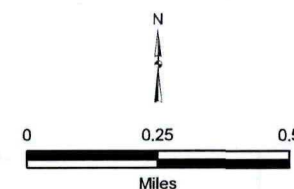
PROJECT NO.:





Legend

-  NHDFlowline
-  Open Water
-  County Road
-  Primary Road

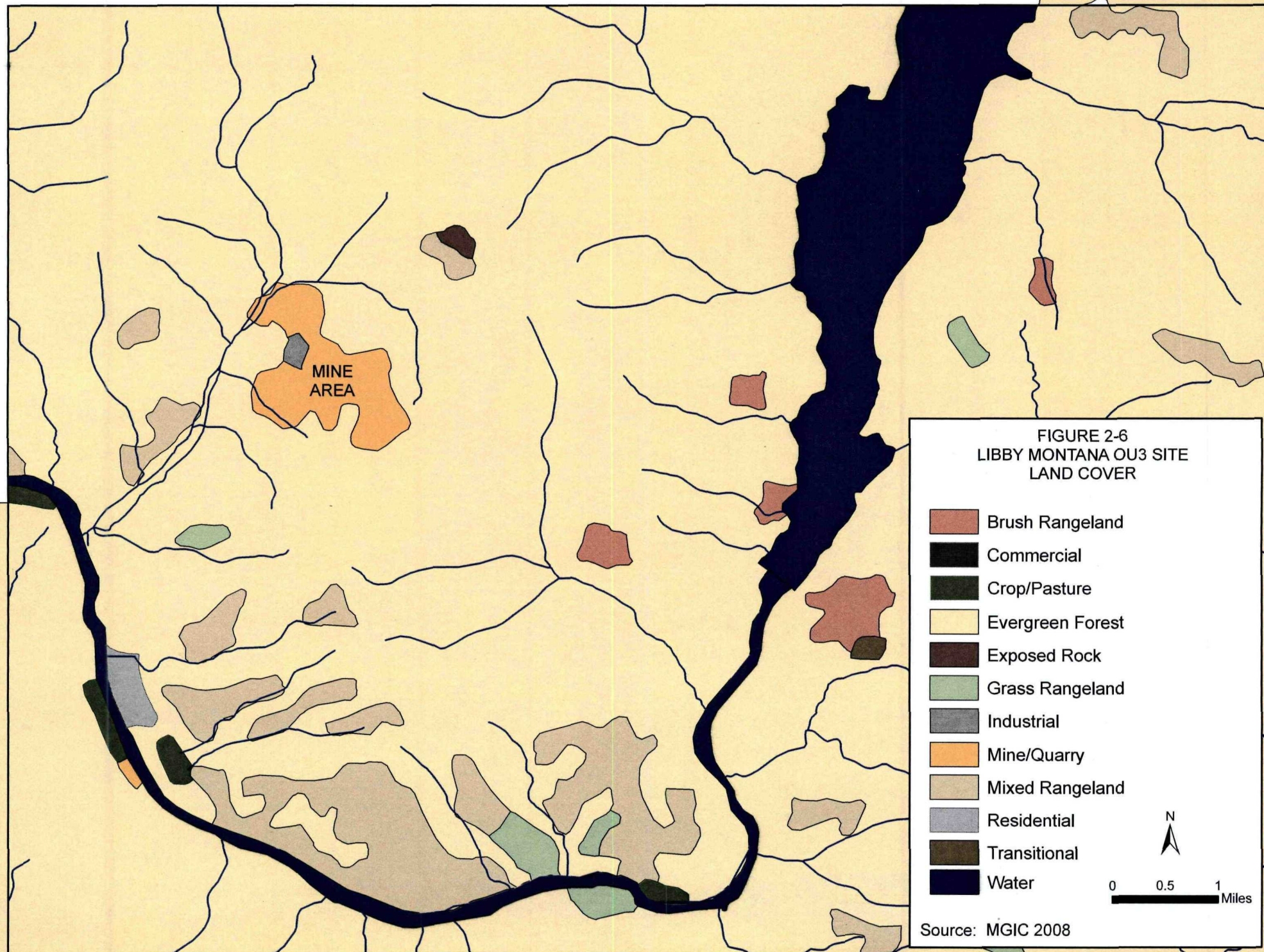


Libby Montana Superfund Site
Operable Unit 3

FIGURE 2-5

MINED AREA FEATURES

PROJECT: 0100-008-900	DATE: AUG 07, 2007
REV: 0	BY: CHECKED: ACK



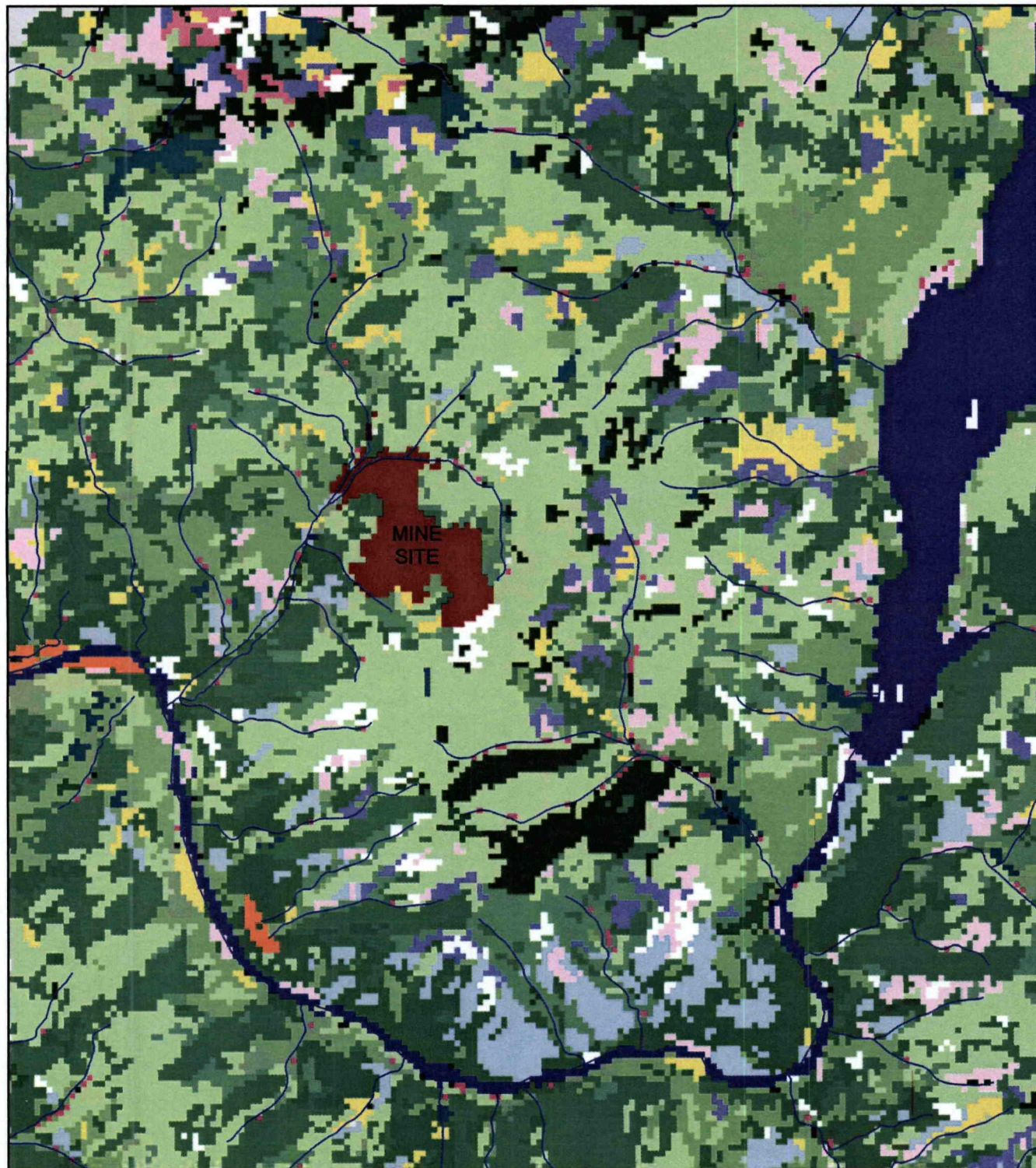


FIGURE 2-7
LIBBY OU3 SITE
VEGETATIVE COVER

AGRICULTURAL & GRASSLANDS

- AGRICULTURAL LANDS - DRY
- LOW/ MODERATE COVER GRASSLANDS

SHRUB COVER TYPES

- MIXED MESIC SHRUBS

RIPARIAN COVER TYPES

- MIXED BROADLEAF
& CONIFER RIPARIAN

FOREST COVER TYPES

- DOUGLAS-FIR
- DOUGLAS-FIR/ LODGEPOLE PINE
- LODGEPOLE PINE
- MIXED BROADLEAF & CONIFER FOREST
- MIXED BROADLEAF FOREST
- MIXED MESIC FOREST
- MIXED SUBALPINE FOREST
- MIXED WHITEBARK PINE FOREST
- MIXED XERIC FOREST
- MONTANE PARKLANDS
& SUBALPINE MEADOWS
- PONDEROSA PINE

OTHER COVER TYPES

- MINES, QUARRIES, GRAVEL PITS
- MIXED BARREN SITES
- ROCK



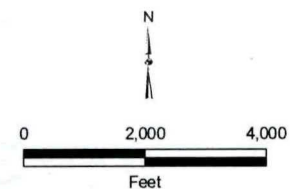
0 0.5 1 2 Miles

Source: USGS 2008



Legend

- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream
- Surface Water/Sediment Sampling Location



LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-8

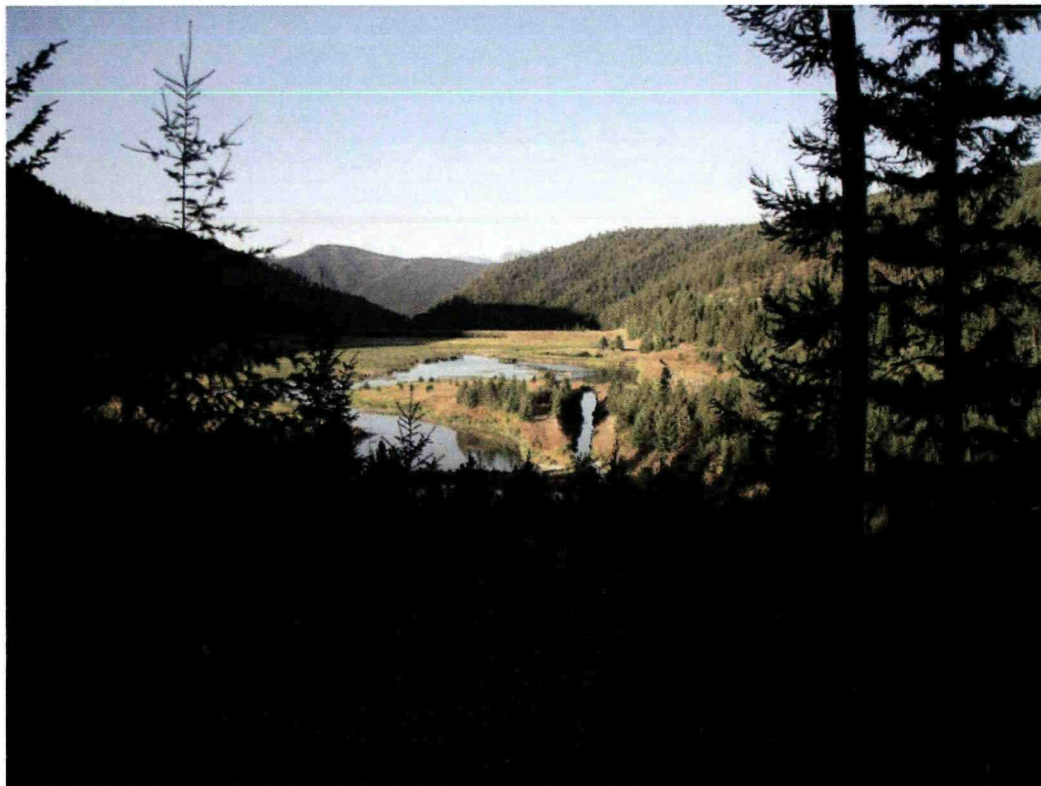
PHASE I SURFACE WATER AND
SEDIMENT SAMPLE LOCATIONS

PROJECT: 0100-008-900 DATE: JAN. 29, 2008
REV: 0 BY: CRL CHECKED: ACK

NEWFIELDS

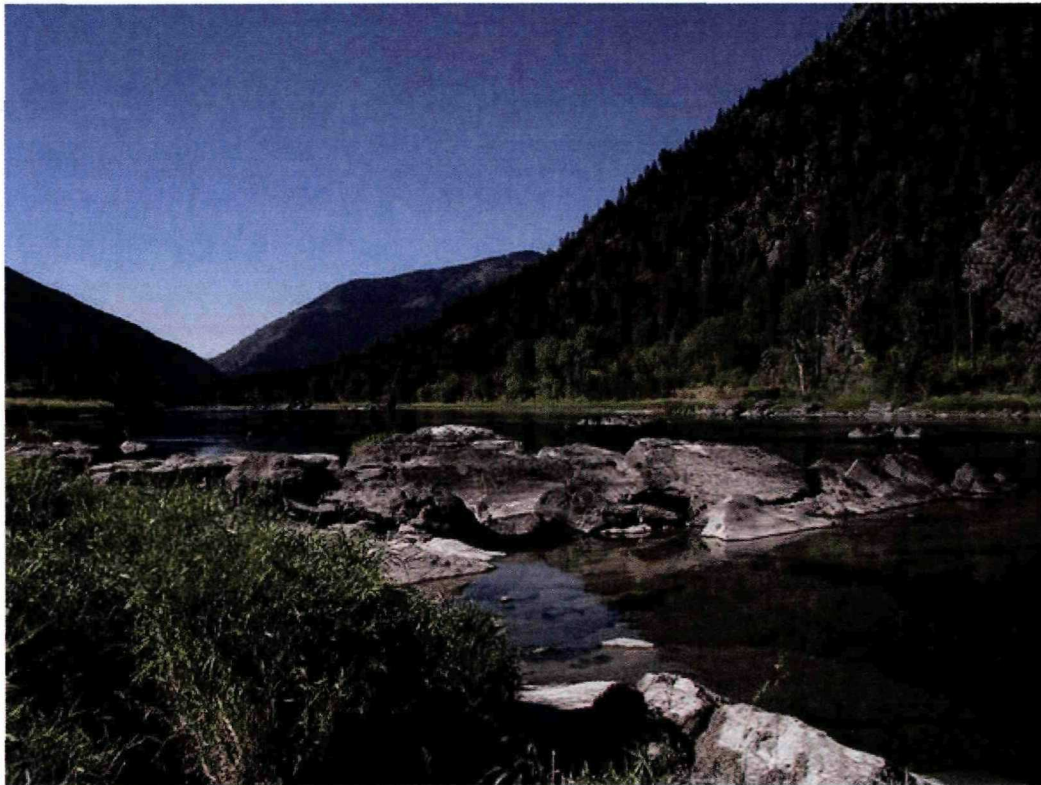


Overview of Mine Site Area



Rainy Creek Drainage

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Kootenai River at Libby



Mill Pond

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Mill Pond



Tailings Impoundment

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Drainage at Toe of Tailings Impoundment



Drainage at Toe of Tailings Impoundment

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area

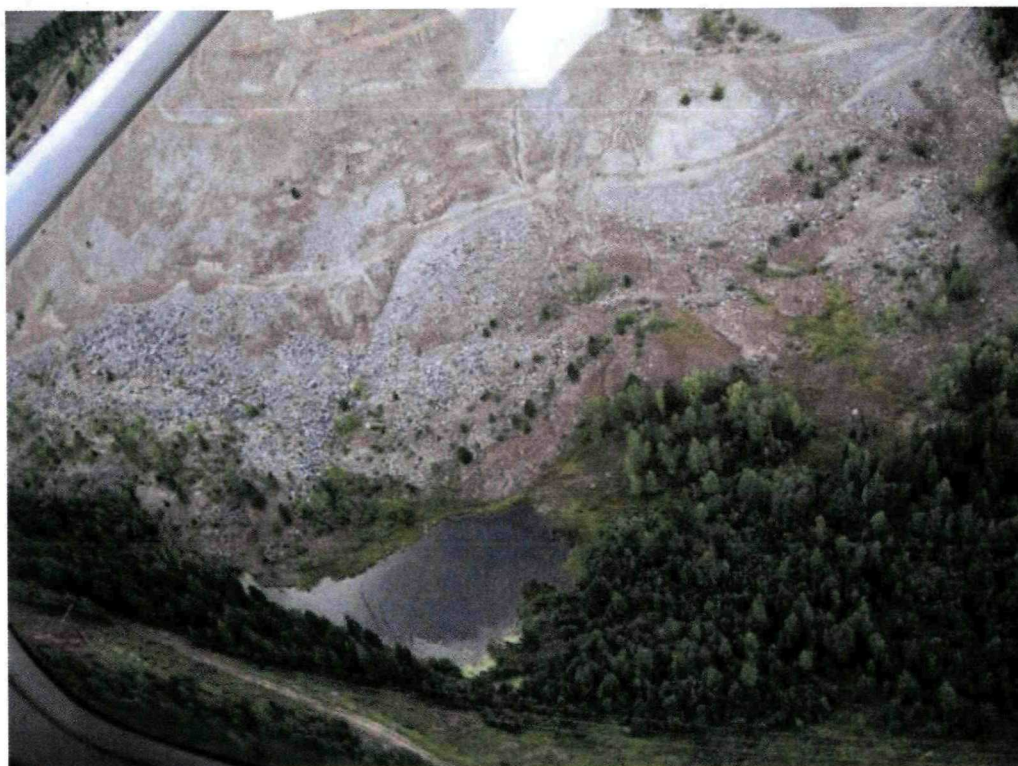


Pond on Fleetwood Creek



Fleetwood Creek

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area

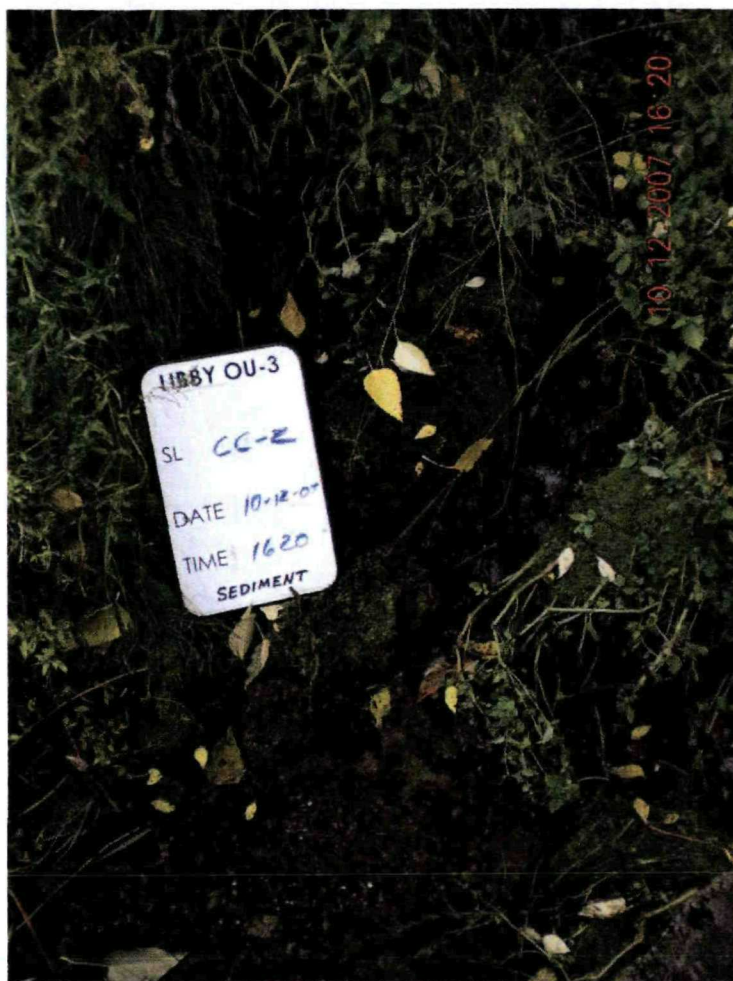


Pond on Carney Creek

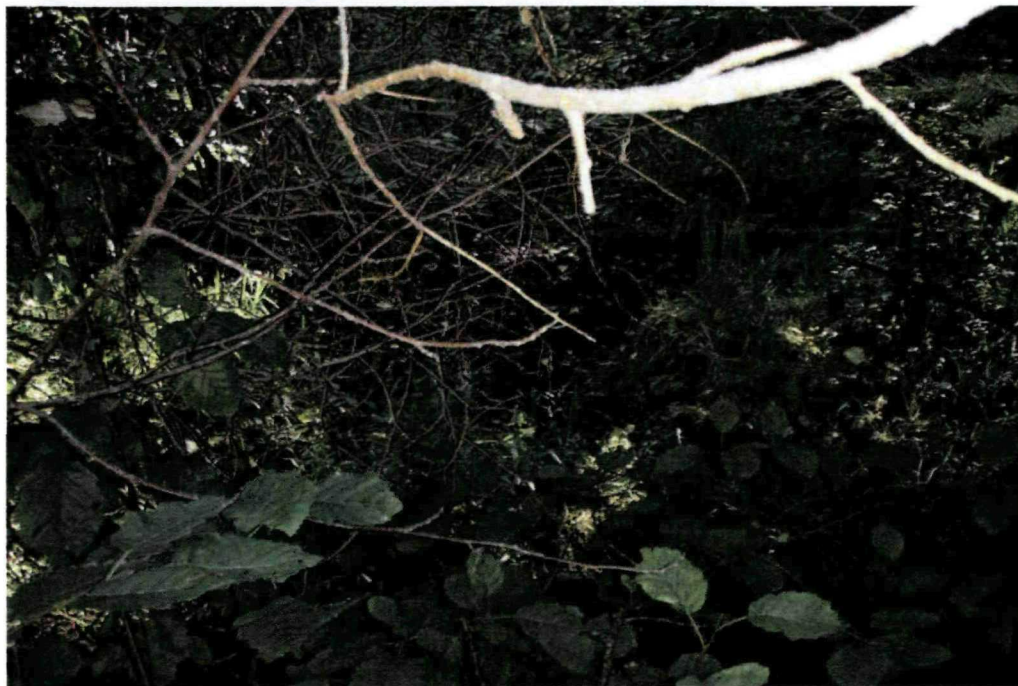


Spring on Carney Creek

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Carney Creek at Confluence with Rainy Creek



Rainy Creek Upstream of Mine Area

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area

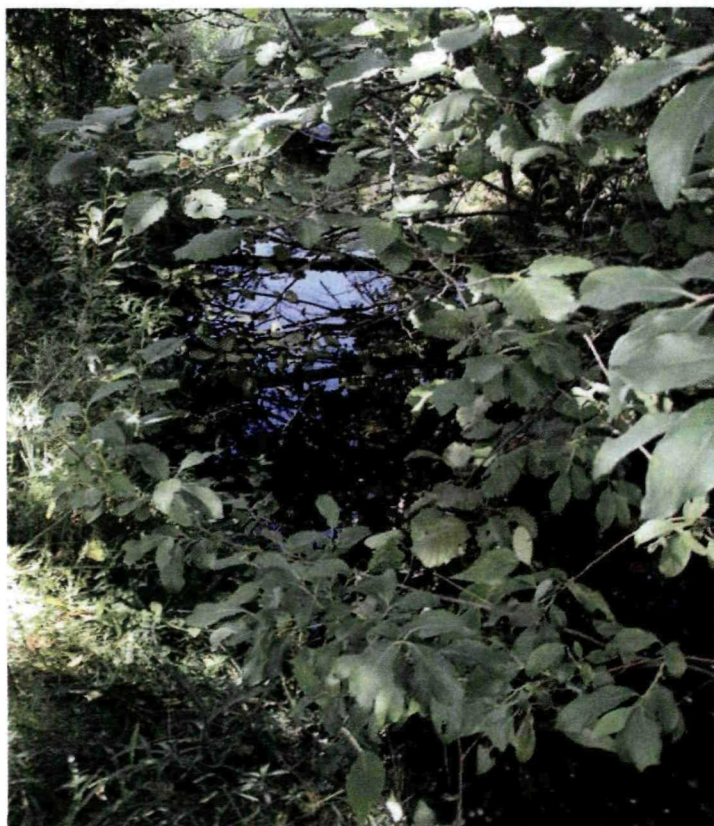


Rainy Creek Culvert



Rainy Creek just Downstream of Mill Pond

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Rainy Creek at Confluence with Carney Creek



Lower Rainy Creek

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area



Lower Rainy Creek



Rainy Creek at Confluence with the Kootenai River

Figure 2-9. Photographs of Aquatic Habitats within OU3 Area

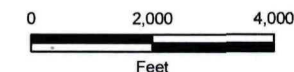


Legend

- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream

Asbestos in Surface Water (Total LA)

- ND - 1 MFL
- 1 - 10 MFL
- 10 - 100 MFL
- > 100 MFL

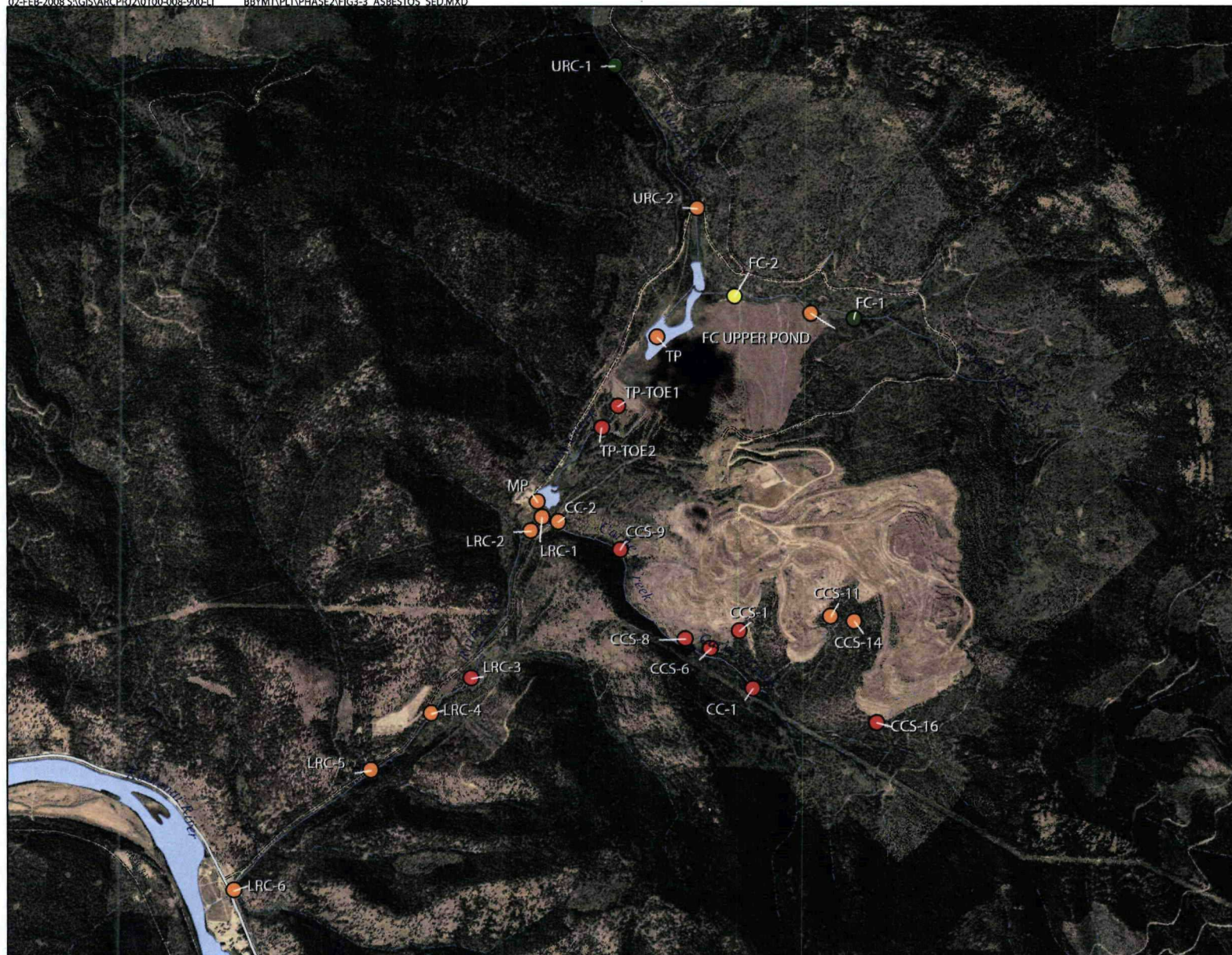


LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-10 ASBESTOS LEVELS IN SURFACE WATER

PROJECT: 0100-008-900	DATE: FEB. 3, 2008
REV: 0	BY: CRL CHECKED:

NEWFIELDS



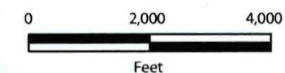
Legend

- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream

Asbestos Levels in Sediment (PLM-VE)

- ND
- B1 (TR)
- B2 (<1%)
- C (2 - 6%)

DRAFT



LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

FIGURE 2-11

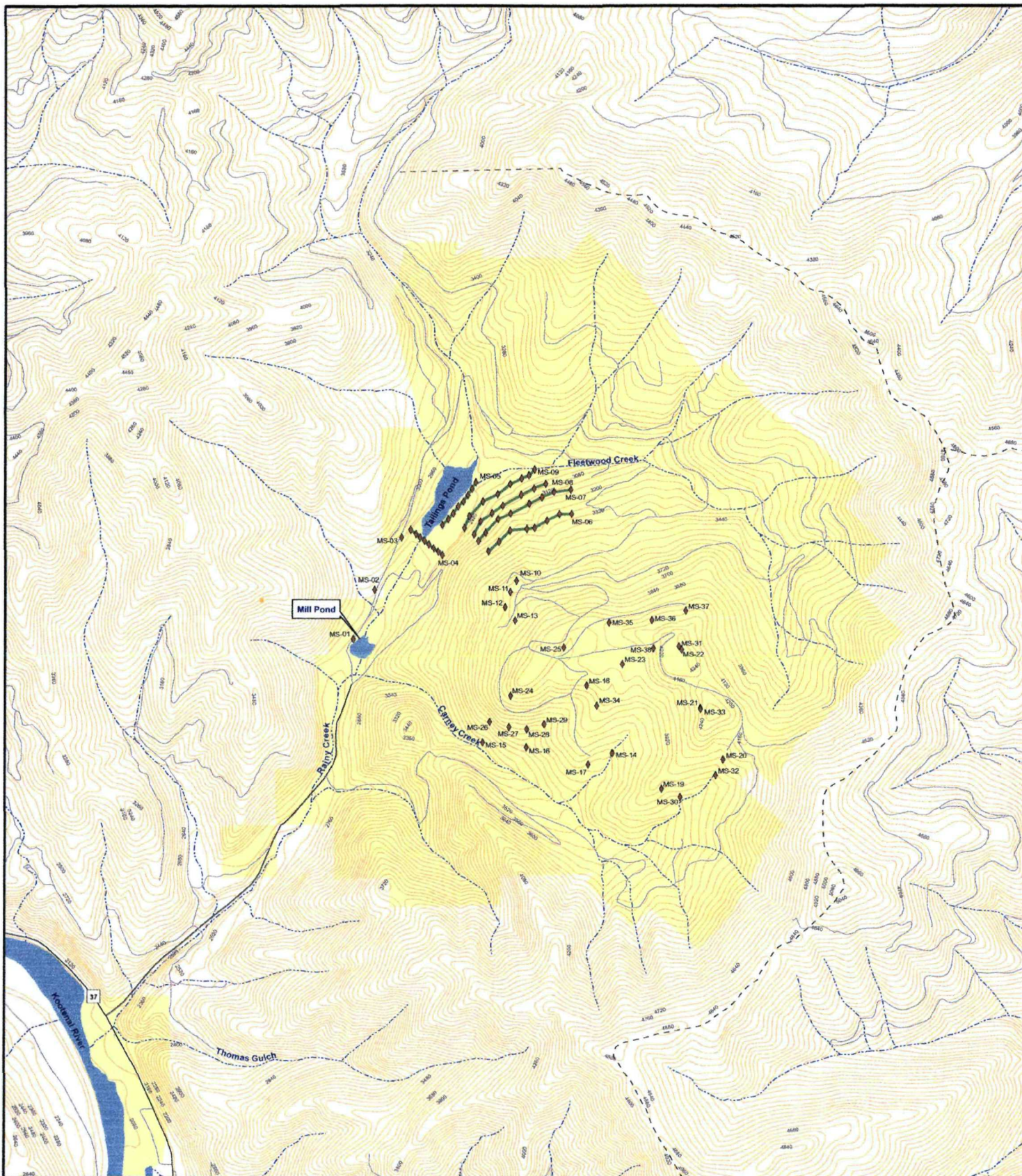
ASBESTOS LEVELS IN SEDIMENT

Data not yet validated

PROJECT: 0100-008-900 DATE: FEB. 2, 2008

REV: 0 BY: CRL CHECKED:

NEWFIELDS



Scale

0 0.125 0.25 0.5 0.75 1 Miles

Legend

- Trails
- Roads
- Lakes
- Streams
- ◆ Mine Waste Sample Location
- Composite Sample Transect
- 40-ft Elevation Contours
- Yellow Former Mine Property

Figure 2-12

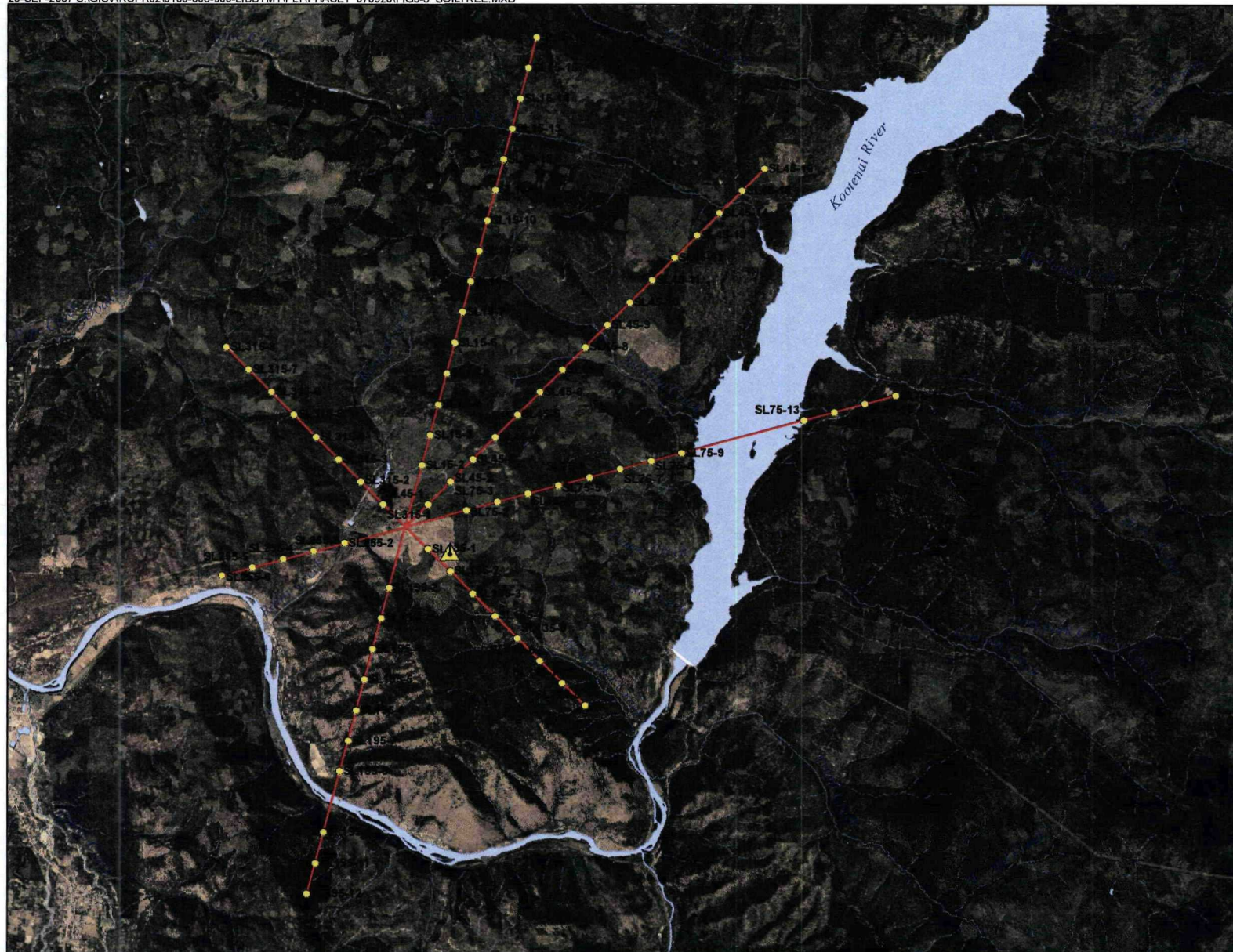
Mine Waste and Soil Sample Locations

LIBBY ASBESTOS SUPERFUND SITE

OU3 PHASE 1 REMEDIAL INVESTIGATION

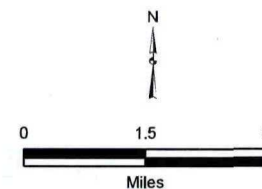
MWH

12/08/2007



Legend

- Soil/Tree Bark Sampling Location
- Open Water
- Perennial Stream
- Intermittent Stream



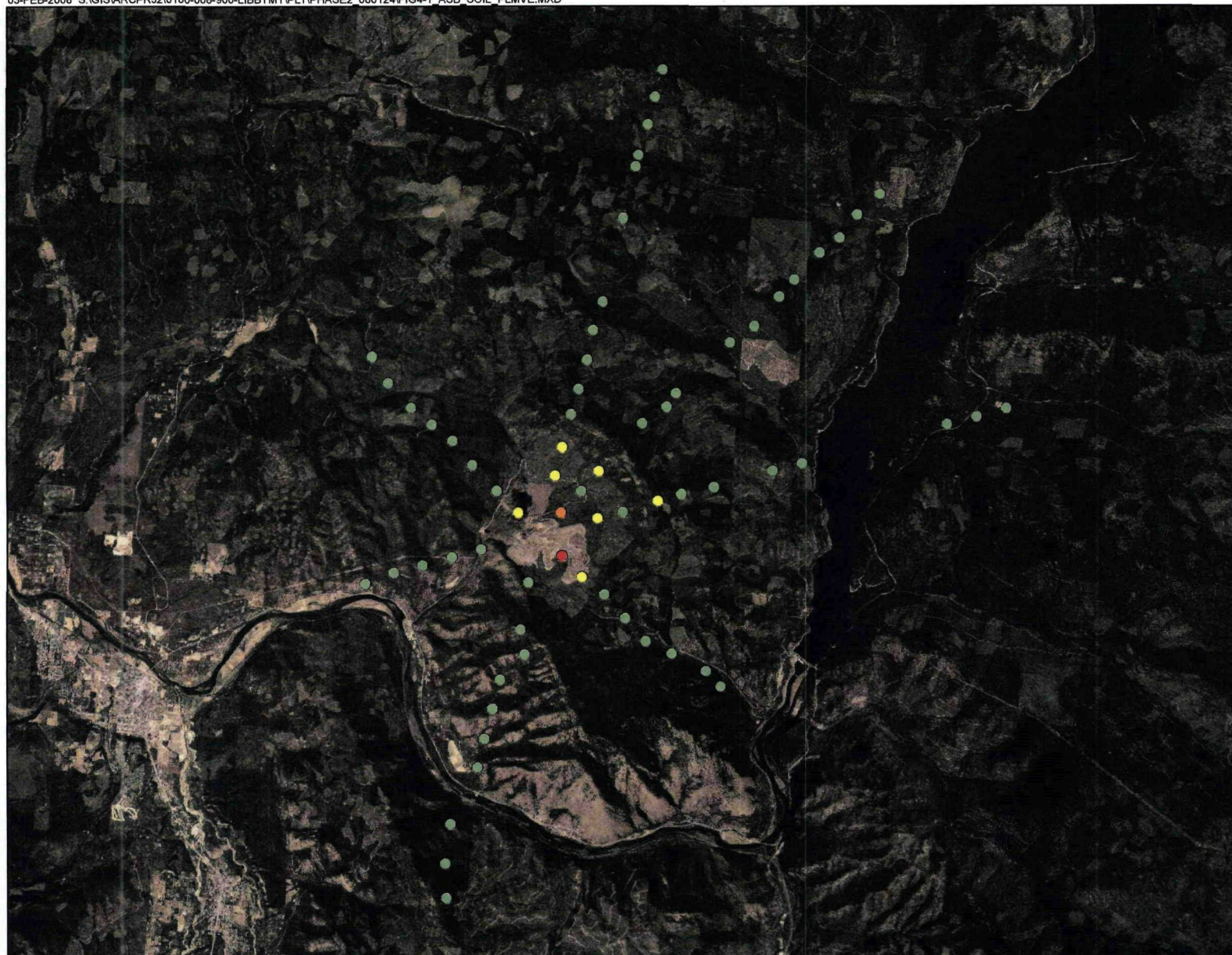
LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-13

**SOIL / TREE BARK
SAMPLING LOCATIONS**

PROJECT: 0100-008-900	DATE: AUG 28, 2007
REV: 0	BY: CRL CHECKED: ACK

NEWFIELDS

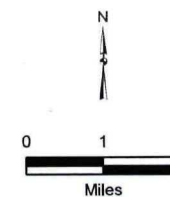


Legend

Asbestos Levels in Soil (PLM-VE)

- ND
- B1 (TR)
- B2 (<1%)
- C (2 - 6%)

DRAFT



LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-14

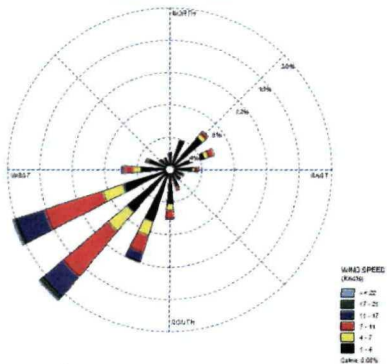
ASBESTOS LEVELS IN FOREST SOILS

Data not yet validated

PROJECT: 0100-008-900 DATE: FEB.11, 2008
REV: 0 BY: CRL CHECKED:

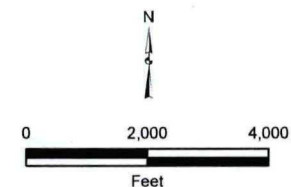
NEWFIELDS

MEASURED WIND DATA FROM THE MINE,
JAN. 26 - AUG. 3, 2007



Legend

- Air Monitoring Location
- Meteorological Station
- Open Water
- Perennial Stream
- Intermittent Stream



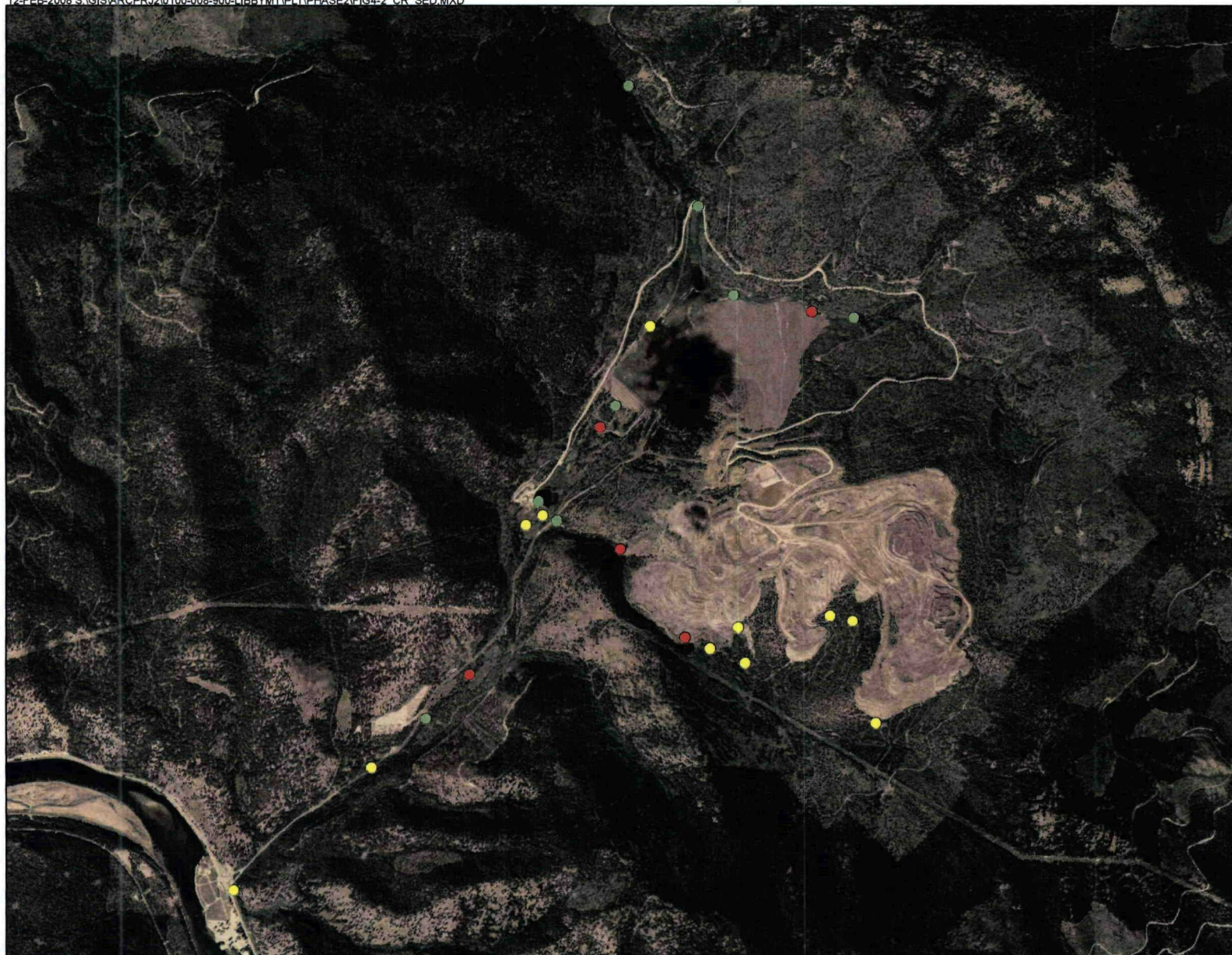
LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-15

AIR MONITORING LOCATIONS

PROJECT: 0100-008-900 DATE: SEP 28, 2007
REV: 1 BY: CRL CHECKED: ACK

NEWFIELDS

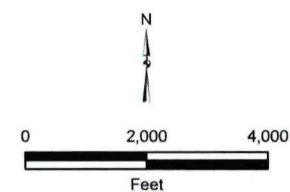


Legend

Chromium Concentrations in Sediments

- < 50 ppm
- 50 - 200 ppm
- > 200 ppm

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LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 2-16
CHROMIUM CONCENTRATIONS
IN SEDIMENTS

PROJECT: 0100-008-900	DATE: FEB. 12, 2008
REV: 0	BY: CRL CHECKED:

NEWFIELDS

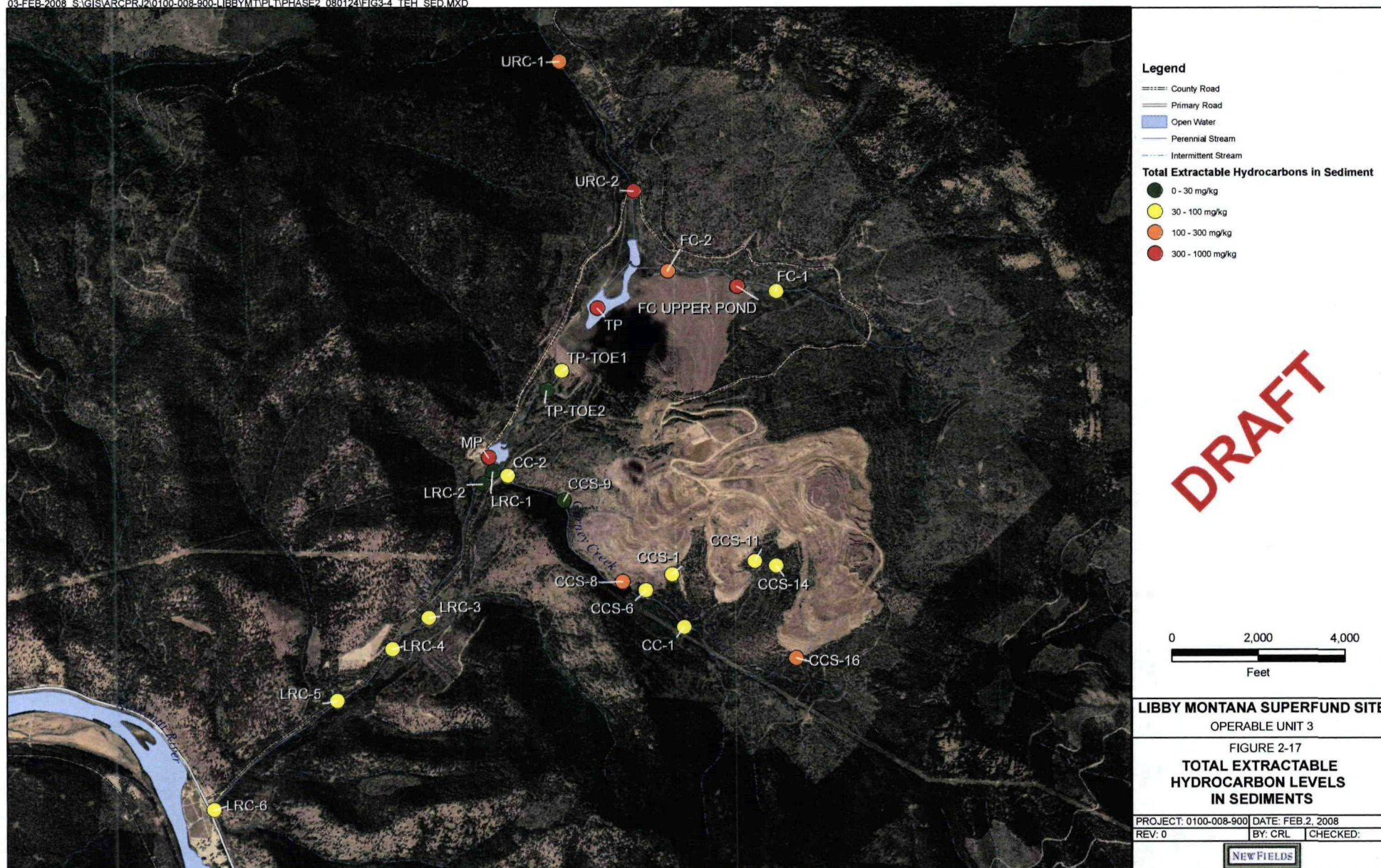


Figure 3-1. Conceptual Site Model for Exposure of Ecological Receptors to Non-Asbestos Contaminants at OU3

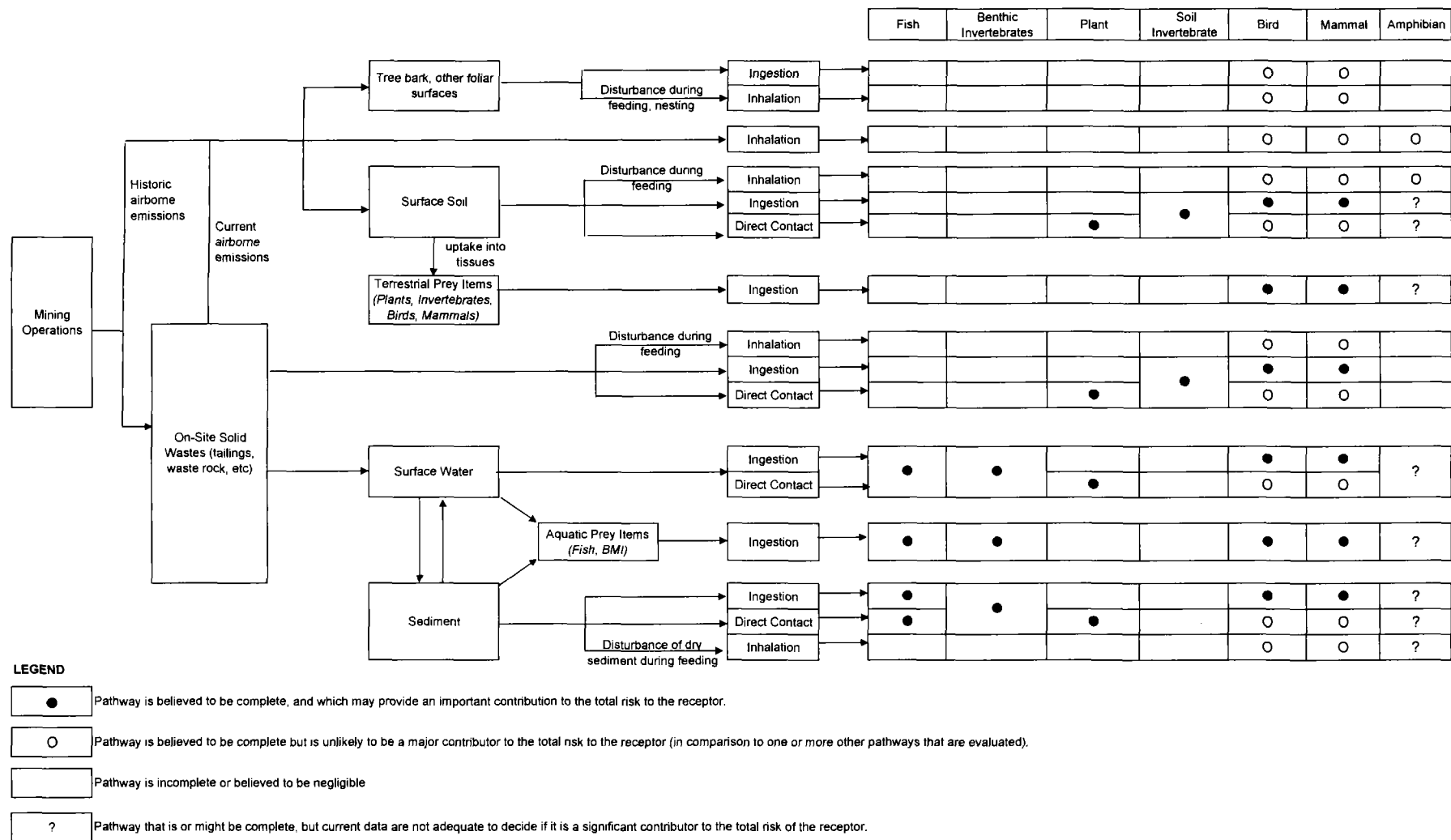
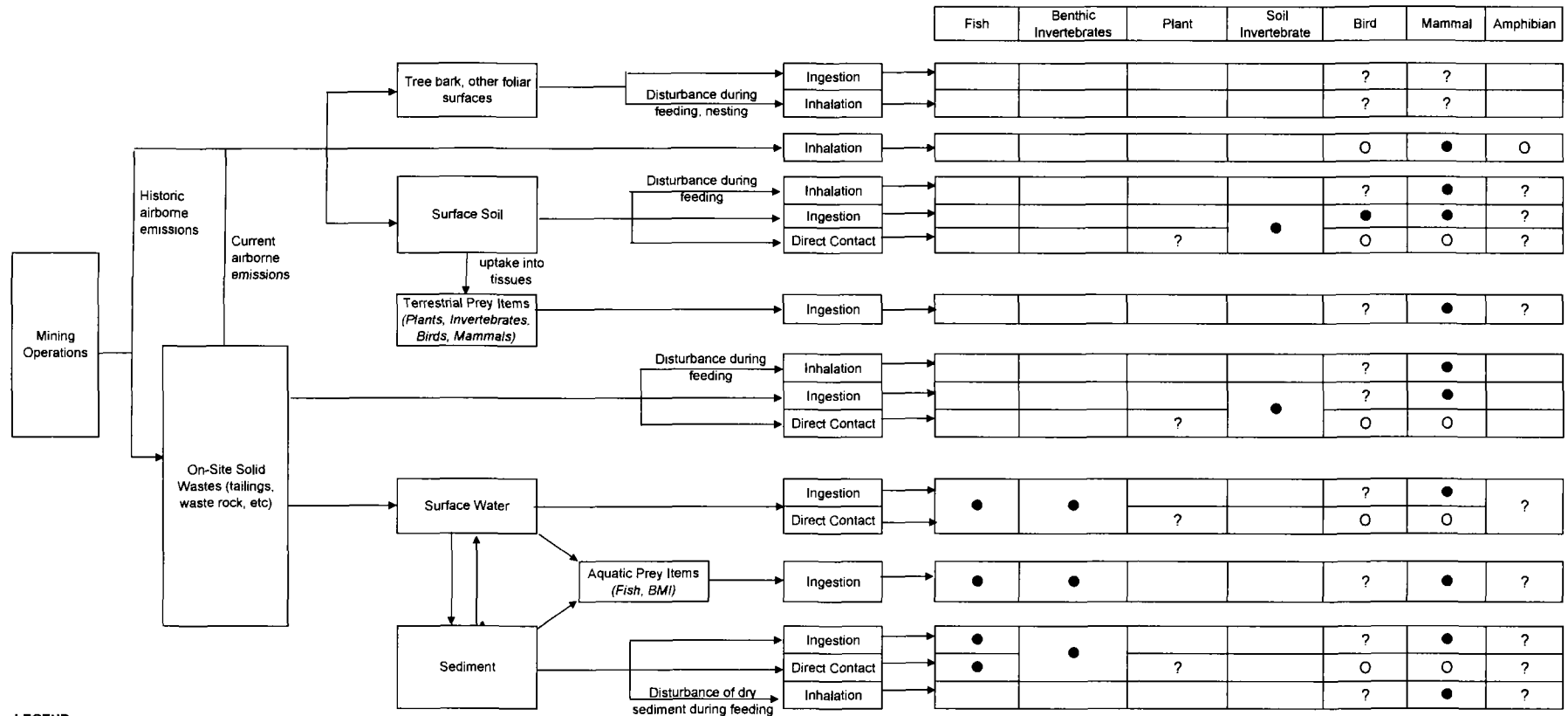


Figure 3-2. Conceptual Site Model for Exposure of Ecological Receptors to Asbestos at OU3



**FIGURE 5-1
STRATEGY FOR EVALUATION OF
RISKS FROM NON-ASBESTOS CONTAMINANTS**

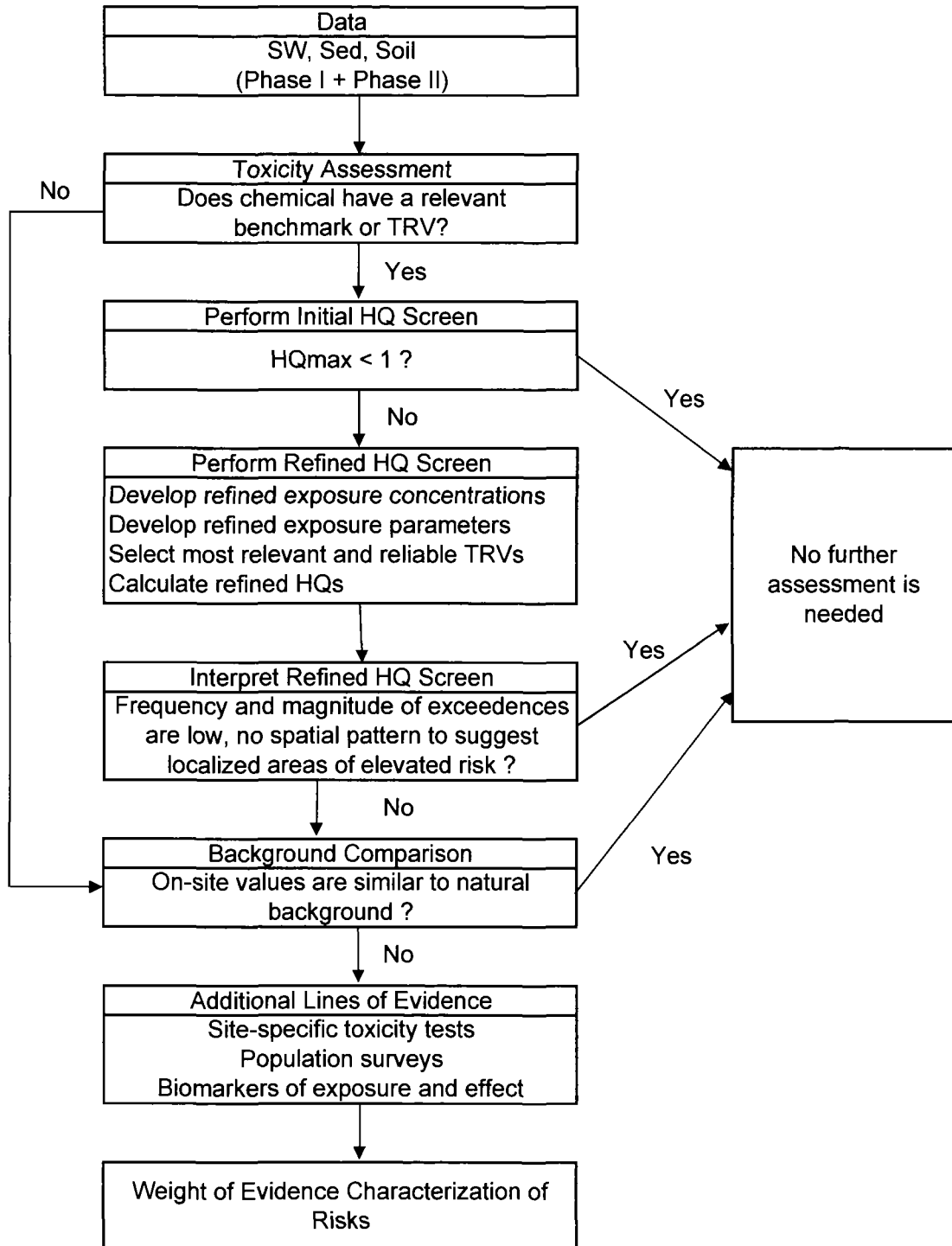


FIGURE 6-1
STRATEGY FOR SITE-SPECIFIC TESTING OF
RISKS TO AQUATIC ORGANISMS FROM ASBESTOS IN SURFACE WATER

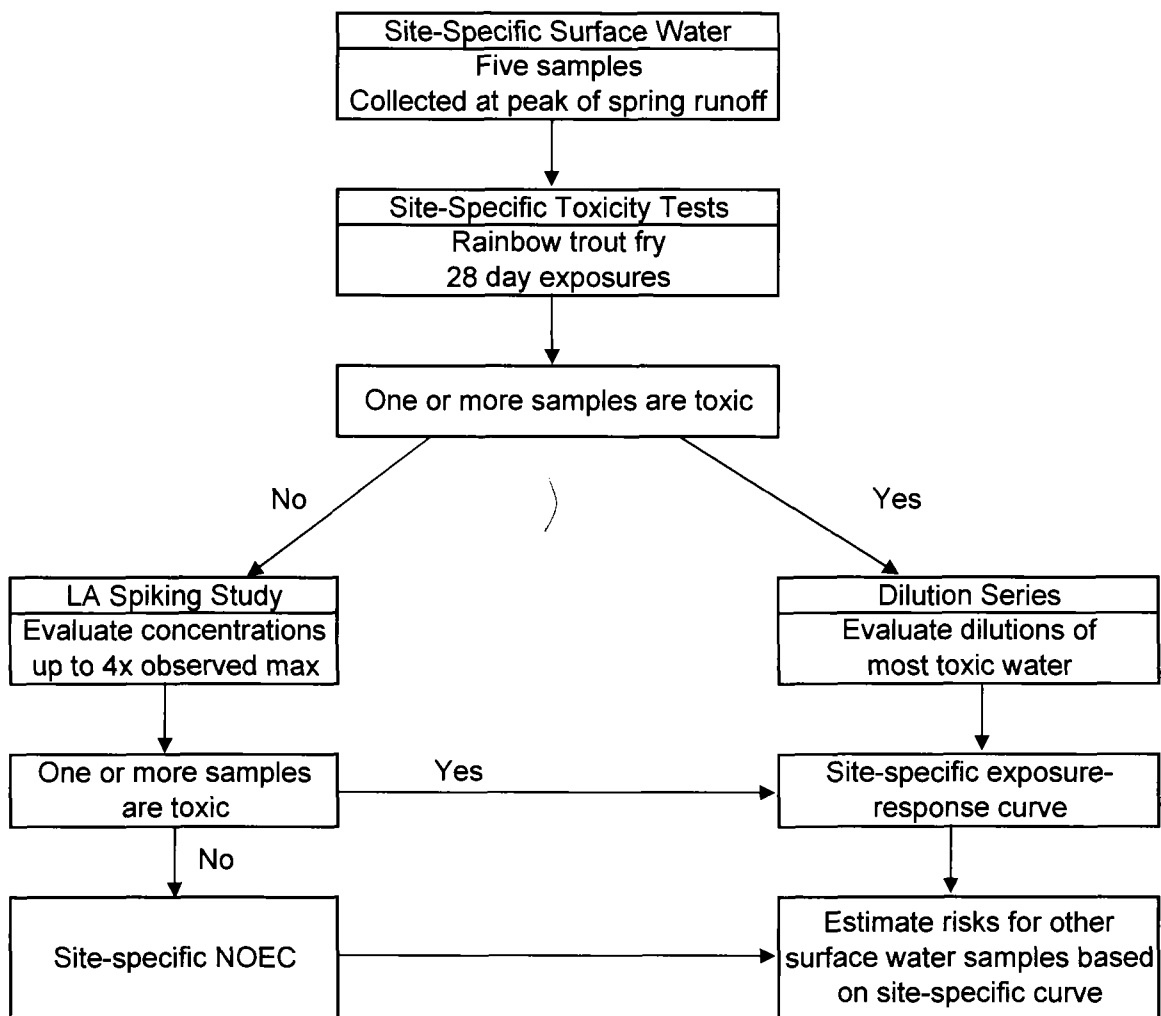
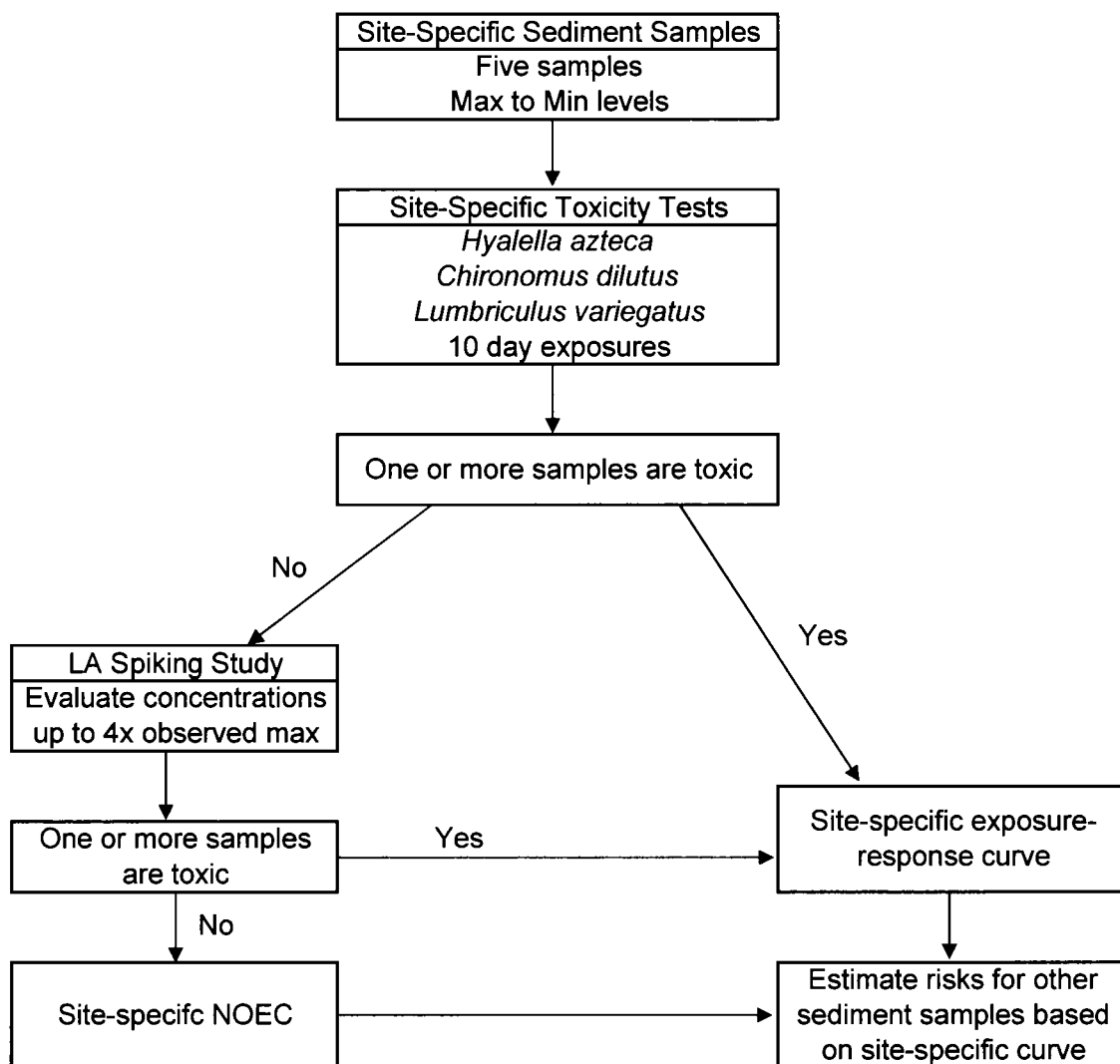


FIGURE 6-2
STRATEGY FOR SITE-SPECIFIC TESTING OF
RISKS TO BENTHIC INVERTEBRATES FROM ASBESTOS IN SEDIMENT



DRAFT - FOR BTAG REVIEW AND DISCUSSION ONLY

ATTACHMENT A
SPECIES INFORMATION

Attachment A-1. Amphibian Species Occurring within the Libby OU3 Site
Page 1 of 32

Group	Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/Hibernation	Longevity	Size		Global Rank	State Rank	Observation in Lincoln, Co., Montana		
		Foraging	Nesting										Oldest	Most Recent	Number
Chorus Frogs (Hylidae)	Pacific Treefrog (<i>Pseudacris regilla</i>)	Aquatic	Aquatic	Regularly found in the water only during the breeding period in spring. In western Montana they breed in temporary ponds in lower elevation forests and intermountain valleys shortly after snowmelt. Eggs hatch in 2 to 3 weeks and tadpoles take 8 to 10 week.	NA	NA	NA/NP	NA	NA		G5	S4	1946	2006	101
Family Woodland Salamanders (Plethodontidae)	Coeur d'Alene Salamander (<i>Plethodon idahoensis</i>)	Aquatic	Aquatic	Springs and seeps, waterfall spray zones, and stream edges. More specifically, primary habitats are seepages and streamside talus; they also inhabit talus far from free water (deep talus mixed with moist soil on well-shaded north-facing slopes). In wet w	Invertivore	When above ground, Coeur d'Alene salamanders feed primarily on insects (11 orders documented) and other invertebrates, including millipeds, mites, spiders, harvestmen, snails, and segmented worms. They appear to be opportunistic feeders and generally rest.	NA	NA	NA		G4	S2	1962	2006	102
Tailed Frogs (Ascaphidae)	Rocky Mountain Tailed Frog (<i>Ascaphus montanus</i>)	Aquatic	Aquatic	Small, swift, cold mountain streams. Eggs are laid during late summer and take approximately 4 weeks to hatch. Tadpoles take 1 - 4 years to metamorphose, depending on water temperature. Sexual maturity in Montana is attained at 6 or 7 years of age (the la	Insectivore	Larva feed almost exclusively on diatoms, though also pollen opportunistic, forage at night. Adults in forest near streams. Prey on invertebrates, mainly terres, but also aquatic forms.	NA/NP	NA	NA		G4	S4	1949	2006	43
True Frogs (Ranidae)	Columbia Spotted Frog (<i>Rana luciventris</i>)	Aquatic	Aquatic	Spotted frogs are regularly found at water's edge in or near forest openings. Wetlands at or near treeline are also used, but populations are uncommon in large, open intermountain valleys. Breeding takes place in lakes, ponds (temporary and permanent), sp	NA	Larvae: veg (Callitriche/Spirogyra) in Yellowstone. Adults: mainly ground insects in W MT: coleoptera 35%, hymenoptera 22%, arachnid 15%, others < 10%.	NA	NA	NA		G4	S4	1922	2007	309
True Salamanders (Plethodontidae)	Long-toed Salamander (<i>Ambystoma macrodactylum</i>)	Aquatic	Aquatic	Variety of habitats from sagebrush to alpine. They typically breed in ponds or lakes, usually those without fish present.	Insectivore	Larv: ostracods/cyclope; also red water mites, insect egg masses, algae. Adult: terres: arthropods (mostly formicid coleop, diptera) 74%; sq: insect larv. (mostly tri- chop) 37%.	NA	NA	NA		G5	S4	1962	2007	246
True Frogs (Ranidae)	Northern Leopard Frog (<i>Rana pipiens</i>)	Aquatic	Aquatic	Low elevation and valley bottom ponds, spillway ponds, beaver ponds, stock reservoirs, lakes, creeks, pools in intermittent streams, warm water springs, potholes, and marshes. There is no evidence that this species in Montana has occupied high elevation wetlands, in contrast to Wyoming and Colorado.	Invertivore	Metamorphosed frogs eat various small invertebrates, including various insects, spiders, leeches, and snails obtained along the water's edge or in nearby meadows or fields. They rarely eat small vertebrates. Larvae eat algae, plant tissue, organic debris, and probably some small invertebrates. In Montana, adults have been documented feeding on 10 orders of insects, spiders, mites, harvestmen, centipeds, millipeds, snails, and newly metamorphosed boreal toads.	NA	NA	NA		G5	S1S3	1922	2006	14
True Toads (Bufonidae)	Western Toad (<i>Bufo boreas</i>)	Aquatic	Aquatic	Habitats used by boreal toads in Montana are similar to those reported for other regions, and include low elevation heavy ponds, reservoirs, streams, marshes, lake shores, potholes, wet meadows, and marshes, to high elevation ponds, fens.	Insectivore	Five insect orders; spiders, daddy longlegs, and millipeds.	NA/NP	NA	NA		G4	S2	1949	2006	126

Montana Species Ranking Codes: Montana employs a standardized ranking system to denote global (G - range-wide) and state status (S) (NatureServe 2003). Species are assigned numeric ranks ranging from 1 (critically imperiled) to 5 (demonstrably secure), reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks - the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat.

G1 S1

At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.

G2 S2

At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to global extinction or extirpation in the state.

G3 S3

Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas.

G4 S4

Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern.

G5 S5

Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.

Attachment A-2. Bird Species Occurring within the Libby OU3 Site
Page 2 of 32

Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
American Bittern (<i>Botaurus lentiginosus</i>)	Riparian	Riparian	Freshwater wetlands with tall, emergent vegetation. Sparsely vegetated wetlands occasionally, tidal marshes rarely.	Aquatic Invertivore	Mainly insects, amphibians, crayfish and small fish and mammals.	Migratory	NA	706 g	NA	G4	S4B	1991	2006	3
American Coot (<i>Fulica americana</i>)	Riparian	Riparian	Marshy borders of ponds	Herbivore	Grains, grasses, and agricultural crops on land; however, it generally forages in or under water, where it is almost exclusively an herbivore	Migratory	NA	724 g	NA	G5	S5B	1991	2006	9
American Crow (<i>Corvus brachyrhynchos</i>)	Scavenger	NA	One of the most widespread of North American birds. Found in a wide variety of habitats, particularly in open landscapes, with scattered trees and small woodlots. Uses both natural habitats and those created by humans (logged, areas, agricultural fields, cities, and villages). Generally avoids large areas of forest	Omnivore	Wide variety of invertebrates (terrestrial and intertidal marine); amphibians; reptiles; small birds and mammals; birds' eggs, nestlings and fledglings; grain crops; seeds and fruits; carrion; and discarded human food	Migratory	NA	316-575 g	spring-summer home range averaged 2.6 sq km	G5	S5B	1992	2006	40
American Dipper (<i>Cinclus mexicanus</i>)	Riparian	Riparian	Prefers fast-moving, clear streams along with waterfalls. Species prefers sand, pebble, or rocky stream bottoms, which provide sufficient aquatic invertebrates. Shorelines with large boulders, fallen trees, and rubble provide good shelter and protection from predators.	Aquatic Invertivore	aquatic invertebrates, insects, and insect larvae. Occ	Non-Migratory	NA	6 g	reported defense of up to 320 meters of stream in breeding season, and from 46-820 meters in nonbreeding season. Year-round density was 1.3 to 2.9 birds per kilometer of stream.	G5	S5	1991	2005	20
American Goldfinch (<i>Carduelis tristis</i>)	Arboreal/Shrub/Ground	NA	Widely distributed in temperate North America. Common in weedy fields, river flood plains, early second growth forest, and also cultivated lands, roadsides, orchards and gardens. in shaded locations under canopy of leaves or dense cluster of needles.	Granivore	Feeds on seeds (e.g., birches, alders, conifers, thistles, goldenrod, etc.); eats some berries and insects. Small seeds of various trees. Insects only as encountered.	Migratory	NA	13 g	NA	G5	S5B	1991	1998	15
American Kestrel (<i>Falco sparverius</i>)	Ground	Arboreal/Climbs/Cavity	found in nearly all habitats in Montana. Nests are often located in cavities in trees, banks, cliffs, and buildings. They also use man-made nest boxes. They usually hunt in open habitat. Kestrels often perch on overhead wires or posts while looking for prey, or hover in midair. In Bozeman area, summer birds are concentrated in the valley, but some birds are found far up mountain canyons; wintering birds tend to frequent irrigated areas	Carnivore	During the summer, kestrels feed heavily on large insects such as grasshoppers. Other prey includes small birds, rodents, and snakes. During winter they feed primarily on small birds and rodents.	Migratory	NA	160 g	Average territory size was 109.4 ha and 129.6 ha in two western U.S. studies (Cade 1982); home range diameter during the breeding season ranged from about 0.5 to 2.4 km in different region.	G5	S5B	1991	2006	49
American Redstart (<i>Setophaga ruticilla</i>)	Arboreal	Shrub	prefers second growth, deciduous woodlands usually near water. Often found in shrubby areas, along with alder and willow thickets	Invertivore	mainly of insects. In late summer months, small berries and fruits. Eats mostly forest tree insects, also spiders and some fruits and seeds	Migratory	NA	9 g	Less than 2 ha	G5	S5B	1991	2005	38
American Robin (<i>Turdus migratorius</i>)	Ground	Arboreal/Shrub	Most widespread North American thrush. Frequents forest, woodland, and gardens, breeding primarily where lawns and other short-grass areas are interspersed with shrubs and trees, such as residential areas, towns, farmyards, and parks.	Invertivore	Eats worms, insects, and other invertebrates (mostly obtained on ground), and small fruits	Migratory	NA	77 g	Territory sizes average 3.65 acres in Douglas fir forests in western Montana.	G5	S5B	1991	2006	828
American Three-toed Woodpecker (<i>Picoides dorsalis</i>)	Arboreal	Dead tree - Cavity	Nesting habitat includes coniferous forests (with spruce, larch, or fir trees), or logged areas and swamps. A cavity nest is dug by both sexes and is placed 1.5 to 15 meters (5 to 50 feet) high in a stump or other dead or dying trees, often near water.	Invertivore	larvae of bark beetles. Also, tree sap and insects.	NA	NA	NA	breeding density hit 13.5 birds per 100 acres in lodgepole pine during a pine beetle epidemic, probably due to the ability of birds to nest in lodgepole pine. In Oregon, home ranges for 3 radioed individuals were 751, 351, and 131 acres.	G5	S3S4	1992	2005	57
American Wigeon (<i>Anas americana</i>)	Riparian	Riparian	Breeds near shallow, freshwater wetlands: sloughs, ponds, small lakes, marshes, and rivers. For nesting prefers areas with upland cover of brush/grass vegetation in the vicinity of lakes or marshy sloughs.		During winter and migration almost entirely vegetarian - stems and leafy parts of aquatic plants leafy parts of upland grasses and leafy parts and seeds of various agricultural crops. During breeding season there is a shift toward a greater proportion of seeds and fruits and a substantial shift toward more nonplant foods - insects, mollusks and crustaceans.	Migratory	NA	792 g	NA	G5	S5B	1986	2005	5

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Riparian	Arboreal	Riparian and lacustrine habitats (forested areas along rivers and lakes), especially during the breeding season. Important year-round habitat includes wetlands, major water bodies, spring spawning streams, ungulate winter ranges and open water areas. Nesting sites are generally located within large forested areas near large lakes and rivers where nests are usually built in the tallest, oldest, large diameter trees. Nesting site selection is dependent upon maximum local food availability and minimum disturbance from human activity	Piscivore	The majority of diet is comprised of fish. Important prey for Bald Eagles are waterfowl, especially in the winter, salmonids, suckers, whitefish, carrion and small mammals and birds	Non Migratory	First breeds in 5-6 yr	5244 g	Defended territories are 11-45 hectares and average 23 ha and territory radius around active nests averaged 0.6 km. Feeding home ranges 7 square kilometers breeding home ranges averaged 21.6 square kilometers	G5	S3	1983	2005	325
Bank Swallow (<i>Riparia riparia</i>)	Riparian	Ground	Breeds primarily in lowland areas along ocean coasts, rivers, streams, lakes, reservoirs, and wetlands. Nesting colonies also found in artificial sites such as sand and gravel quarries and road cuts. Most rivers and streams with nesting habitats are low-gradient, meandering waterways with eroding streamside banks.	Aquatic Invertivore	Takes flying or jumping insects almost exclusively on the wing. Occasionally eats terrestrial and aquatic insects or larvae. Rare consumption of vegetable matter appears to be accidental.	Migratory	1 -2 yr	15 g	Most foraging flights within 0.8 kilometers of colony	G5	S5B	1993	1999	8
Barn Swallow (<i>Hirundo rustica</i>)	Aerial	Buildings	Originally nesting primarily in caves, it has almost completely converted to breeding under the eaves of or inside artificial structures such as buildings and bridges. Presently found in various habitats, including agricultural areas, cities, suburbs, and along highways. Breeding habitat usually contains open areas (fields and meadows) for foraging, a nest site that includes a vertical or	Aerial Invertivore	Flying insects. Flies over open land and water and forages on insects; forages nearer to the ground than other swallows (usually not greater than 10 meters and often less than 1 meter above the ground). Feeds opportunistically on a wide variety of flying insects	Migratory	NA	17-20 g	Usually forages within a few hundred meters of nest when breeding.	G5	S5B	1991	2005	14
Barred Owl (<i>Strix varia</i>)	Carnivore	NA	Restricted to forested areas, ranging from swamps and riparian areas to upland regions. Large, unfragmented blocks of forests preferred. Throughout its range, found in association with mature and old growth forests, typically of mixed deciduous-coniferous composition	Carnivore	An opportunistic predator, consuming small mammals and rabbits, birds up to the size of grouse, amphibians, reptiles, and invertebrates	Non-Migratory	NA	801 g	Home range usually is less than 400 ha (but up to 760 ha) over 2-7 months, average 273 hectares	G5	S4	1995	2004	13
Barrow's Goldeneye (<i>Bucephala islandica</i>)	Riparian	NA	Chiefly a bird of the western montane region of North America. This species is generally restricted to areas west of the Continental Divide. Prefers alkaline to freshwater lakes in parkland areas; to lesser extent, subalpine and alpine lakes, beaver ponds, and small sloughs. In summer usually found in small, scattered groups. In winter often seen in large flocks.	Aquatic Invertivore	Aquatic invertebrates (insects, mollusks, crustaceans) and fish eggs. Seeds and tubers provide a small fraction of the diet	Non Migratory	NA	1090 g	NA	G5	S5B	1987	1995	6
Belted Kingfisher (<i>Megasceryle alcyon</i>)	Riparian	Riparian - Burrow	Inhabits streams, rivers, ponds, lakes, and estuaries or calm marine waters in which prey are clearly visible. Availability of suitable nesting sites - earthen banks where nesting burrows can be excavated - appears critical for the distribution and local abundance of this species. Prefers to excavate a nesting burrow near its fishing territory. Needs clear still waters for fishing.	Piscivore	Chiefly fish. Also mollusks, crustaceans, insects, amphibians, reptiles, young birds, small mammals, even berries.	Migratory	NA	148 g	Regularly forages up to 8 km from the nest	G5	S5B	1991	2006	15
Black-backed Woodpecker (<i>Picoides arcticus</i>)	Arboreal	Arboreal	Early successional, burned forest of mixed conifer, lodgepole pine, Douglas-fir, and spruce-fir (Hutto 1995a, 1995b), although they are more numerous in lower elevation Douglas-fir and pine forest habitats than in higher elevation subalpine spruce forest habitats	Invertivore	Bulk of the diet is wood-boring beetle larvae (including <i>Monochamus</i> spp. and <i>Englemann spruce beetle</i> , <i>Dendroctonus englamanni</i>), but they also feed on other insects (e.g., weevils, beetles, spiders, ants). Occasionally they will eat fruits, nuts, sap, and cambium. obtain food by flaking bark from trees (usually dead conifers) and logs, sometimes by picking gleaning. They feed primarily on logs and low on large-diameter tree trunks (more than 7.5 centimeter diameter at breast height; but most often 15-25 centimeter dbh)	Non Migratory	NA	72 g	178, 307, and 810 acres	G5	S2	1987	2005	37
Black-billed Magpie (<i>Pica hudsonia</i>)	Ground	Arboreal	Historically, it frequently followed Native Americans and lived on the refuse of their hunts. In breeding season will be found in thickets in riparian areas, often associated with open meadows, grasslands, or sagebrush for foraging. Less specific in its habitat requirements in nonbreeding season. Frequently numerous near human habitats such as livestock feedlots, barnyards, landfills, sewage lagoons, and grain elevators. Nests are durable, domed structures of sticks, with mud cup and anchor. Generally prefers high trees. Have been know to nest on utility poles.	Omnivore	Ground-dwelling arthropods, seeds, and carrion	Non Migratory	NA	189 g	NA	G5	S5	1993	1998	12

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Black-capped Chickadee (<i>Parus atricapillus</i>)	Arboreal/ Shrubs	Arboreal - Cavity	Deciduous and mixed deciduous/coniferous woodland, open woods and park willow thickets, and cottonwood groves. Also disturbed areas such as old fields or suburban areas. Generally more common near edges of wooded areas. Nests in cavities. Natural sites typically in trees, especially dead snags or rotten branches, sometimes old woodpecker holes or even in bird boxes.	Invertivore	Eats mainly insects and other small invertebrates, and their eggs and immature stages, and seeds and fruits; forages mainly on woody twigs, branches, and stems	Non Migratory	NA	11 g	Territory size averaged about 8.9 ha	G5	S5	1992	2006	316
Black-chinned Hummingbird (<i>Archilochus alexandri</i>)	Shrub/Ground	Riparian	In the arid western portion of range, nests in environments that often include cottonwood, sycamore, willow, salt-cedar, sugar-berry, and oak. In most regions, its preferred habitat is a canyon or flood-plain riparian community. Nests typically in riparian habitats. Nest is a cup shape, primarily composed of plant down.	Nectarivore	Main foods taken include nectar from flowers; small insects and spiders; sugar water from feeders provided by humans	Migratory	NA	4 g	NA	G5	S4B	1993	2006	19
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	Arboreal	Arboreal	Occupies diverse habitats. Cottonwood/willow groves and other riparian habitats in desert and dry grassland; openings in mature pine forest; aspen groves; deciduous growth especially in mountain valleys/canyons; pinyon-juniper woodlands; oak savanna; gardens; orchards. Relatively tolerant of human disturbance. Nests widely reported to be so thinly constructed that eggs can be seen through bottom. Nests are generally well concealed among foliage of branches.	Omnivore	Insects and spiders; cultivated fruit, wild fruit, weed seeds, and grains. During breeding season, glean insects high in trees and in understory.	Migratory	NA	47 g	NA	G5	S5B	1993	2002	38
Blue Jay (<i>Cyanocitta cristata</i>)	Ground	Arboreal	Primarily inhabits deciduous, coniferous, and mixed forests and woodlands. Common in towns and residential areas, especially those having large oaks or other mast-producing trees.	Omnivore	Arthropods, acorns and other nuts, soft fruits, seeds, small vertebrates.	Migratory	NA	87 g	NA	G5	S5N	1988	2002	5
Blue-winged Teal (<i>Anas discors</i>)	Riparian	Riparian	Main habitat consists of shallow ponds with adequate supplies of aquatic invertebrates. Prefers to nest in grass or herbaceous vegetation and rarely uses brushy nesting cover.	Omnivore	Diet consists of aquatic invertebrates, seeds, vegetative parts of aquatic plants, duckweeds, algae and occasional grains from agricultural crops. Animal matter dominates diet of laying females.	Migratory	NA	409 g	NA	G5	S5B	1992	1998	6
Bohemian Waxwing (<i>Bombus garrulus</i>)	Arboreal	Arboreal	Prefers open coniferous or mixed-coniferous and deciduous forests. Often found in recently burned areas or near lakes and streams, beaver ponds, and swamps.	Frugivore, Invertivore	Sugary fruits and insects. During spring, also tree sap and budding flowers.	Migratory	NA	56 g	NA	G5	SHB, S5N	1920	1993	4
Boreal Chickadee (<i>Parus hudsonicus</i>)	Arboreal	Arboreal	boreal coniferous and mixed forests, muskeg bogs, in the vicinity of white cedar and hemlock swamps, birches and streamside willows. The species nests in natural cavities or abandoned woodpecker holes, or in a cavity dug by a pair in a rotten tree stub, usually within 1 meter of the ground (but up to 3.7 m).	Omnivore	conifer and birch seeds, and the eggs, larval stages, and adults of insects. It forages mainly on twigs and branches of trees.	Non-Migratory	NA	10 g	NA	G5	S1S2	1994	2005	13
Boreal Owl (<i>Aegolius funereus</i>)	Carnivore	Arboreal	High elevation spruce/fir forest, with lodgepole pine sometimes present. Mature spruce/fir forests with multilayered canopies and a highly complex structure, at elevations greater than 1500m with a mosaic of openings or meadows. roost at sites scattered throughout their home range, rarely in the same stand on consecutive nights or the same tree more than 2X per year. Roost alone, usually far from their nest and mate	Carnivore	Predominately small mammals, with a few birds and insects	Non-Migratory	NA	167 g	NA	G5	S4	1986	1996	35
Brewer's Blackbird (<i>Euphagus cyanocephalus</i>)	Ground	NA	Open, human-modified habitats such as residential lawns, golf courses, cemeteries, mowed urban parks and campus areas. Also found in large clearcut forests and plowed fields	Omnivore	During breeding season, diet consists of insects and other invertebrates, along with grains and weed seeds. During migration and winter, diet consists of primarily vegetarian such as waste grains, weed and grass seeds.	Migratory	NA	67 g	NA	G5	S5B	1991	2006	11
Brown Creeper (<i>Certhia americana</i>)	Arboreal	Arboreal	Late successional stages of coniferous forests and mixed coniferous-deciduous forest. Especially common in unlogged, old-growth stands. The consistent factor appears to be the need for large trees and snags (dead trees) for foraging and nesting microsites. Breeding season is the same as winter, but possible no vegetable matter is eaten. Nest built in 2 parts, base and nest cup, behind a piece of peeling bark.	Invertivore	Forages primarily on trunks of live trees. In winter main foods taken include a variety of insects and larvae, spiders and their eggs, ants, and pseudoscorpions; a small amount of seeds and other vegetable matter.	Altitudinal	NA	8 g	Territories ranged from 2.3 to 6.4 ha	G5	S4	1992	2004	225
Brown-headed Cowbird (<i>Molothrus ater</i>)	Ground	Brood parasite	Areas with low or scattered trees among grassland vegetation; woodland edges, brushy thickets, prairies, fields, pastures, orchards, or even residential areas. Species is a brood parasite; nests are chosen by females, but are that of another species. Care given to cowbird eggs and young is provided by the host and reflects characteristics of that species.	Omnivore	Mainly of arthropods and seeds.	Migratory	NA	adult male is 39-57 g, female is smaller	NA	G5	S5B	1992	2006	102

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Bufflehead (<i>Bucephala albeola</i>)	Riparian	Riparian	Freshwater, permanent ponds with no outlet or only seasonal outflow, and small lakes. Large lakes are avoided except by molting flocks. Habit of nesting in the holes of the Northern Flicker. Will also nest in boxes.	Aquatic Invertivore	Main foods taken are aquatic invertebrates (insects, crustaceans, mollusks). Will take some seeds.	Migratory	NA	473 g	NA	G5	S5B	1995	2006	5
Bullock's Oriole (<i>Icterus bullockii</i>)	Arboreal	Arboreal	Prefers open woodland areas, especially riparian (river) woodlands with large cottonwoods, sycamores, and willows. During spring and fall migration it is found in a variety of open woodland and urban parklands and tall shrubland. Nests are typically pendulous, often suspended from a few thin branches.	Invertivore	Mostly insects, especially butterfly and moth larvae and pupae, grasshoppers and crickets, beetles and other insects.	Migratory	NA	34 g	Females foraged regularly more than 200 meters from nest, and up to 1 kilometer	G5	S5B	1993	2004	2
California Gull (<i>Larus californicus</i>)	Riparian	Riparian	Prefers larger lakes, but also occurs on ponds and rivers, especially in spring and fall. Nests varied in shape from depressions in the ground to constructed mounds; they were located 2 to 75 feet apart	Aquatic Invertivore	Insects, oligochaetes, crustaceans, amphibians and birds, and plant material believed to be ingested incidentally to consuming animals	Migratory	NA	609 g	Breeding pairs in MT foraged an average of 17.4 km (maximum 61 km) from colony. At another colony, maximum foraging distance was 32 km	G5	S5B	1991	1995	3
Calliope Hummingbird (<i>Sialia calliope</i>)	Aerial	Arboreal	Mountains; along meadows, canyons and streams. Open montane forest, mountain meadows, and willow and alder thickets, gardens; in migration and winter also in chaparral, lowland brushy areas, deserts. Nests in tree (frequently conifer) at edge of meadow or in canyon or thicket along stream. Nests <1-21 m above ground (usually low, with branch or foliage above). Nectar supply unimportant in location of male's breeding territory. In Bozeman area occurs on thickety hillsides and in forest openings to moderate elevations in the mountains.	Aerial Invertivore	Floral nectar and small insects. Like other hummingbirds, it forages aerially for small insects.	Migratory	NA	3 g	NA	G5	S5B	1991	2004	40
Canada Goose (<i>Branta canadensis</i>)	Ground	Riparian	Various habitats near water, from temperate regions to tundra. In migration and winter, coastal and freshwater marshes, lakes, rivers, fields, etc. Breeds in open or forested areas near lakes, ponds, large streams, inland and coastal marshes. The nest is built on the ground or on an elevated place (muskrat house, abandoned heron's nest, rocky cliffs, etc.). Usually returns to nesting territory used in previous year.	Herbivore	Grazes on marsh grasses, sprouts of winter wheat (spring), grain (fall); eats clover, cattails, bulrushes, algae, pond-weed, and other plants. Feeds in shallows, marshes, fields. Also eats mollusks and small crustaceans	Migratory	Begin breeding at 2 years, most by age 3 years.	4741 g	NA	G5	S5B	1991	2006	33
Canvasback (<i>Aythya valisineria</i>)	Riparian	Riparian	Breeds in small lakes, deep-water marshes, sheltered bays of large fresh water and alkali lakes, permanent and semi permanent ponds, sloughs, potholes, and shallow river impoundments. In aspen parklands and mixed-grass prairie, prefers wetlands bordered by dense emergent vegetation. In boreal forest, utilizes open marshes. Nest is a large bulky structure. May be overtopped by vegetation and may have one or more well-maintained ramps.	Omnivore	Foods vary depending upon availability. During winter and migration, mainly plants (winter buds, rhizomes, and tubers or aquatic plants. When plant food is limited, may take small clams and snails.	Migratory	NA	1248 g	NA	G5	S5B			2
Canyon Wren (<i>Catherpes mexicanus</i>)	Ground	Ground/Climbs and Rock Outcrops	Limited to cliffs, steep-sided canyons, rocky outcrops, and boulder piles, usually in arid regions. Inhabits the same territories year-round. Also sometimes found in towns, around houses and barns, on old stone buildings. Nests on canyon walls; may also nest around human-built structures.	Invertivore	Uses its long, decurved bill and flattened head to probe for spiders and insects in rock crevices	Non-Migratory	NA	39 g	NA	G5	S4	1995	1995	2
Cassin's Finch (<i>Carpodacus cassinii</i>)	Arboreal	Arboreal	Prefers open coniferous forests of interior western mountains along with mature forests of lodgepole pine. Nests in conifer, 3-25 m above ground, on outer end of limb, may sometimes nest in deciduous tree or in shrub. May return to same nesting area in successive years, though this may be unusual	Herbivore	Consists of mostly vegetable matter, particularly buds, seeds, berries and other fruits, along with some insects.	Migratory	Breeds at 1-2 yr	27 g	NA	G5	S5	1990	2004	155
Cassin's Vireo (<i>Vireo cassinii</i>)	NA	NA	Prefer dry, open forests. Occupies coniferous, mixed-coniferous/deciduous, and deciduous forests in mountains and foothills.	Omnivore	Diet consists almost exclusively of arthropods, spring through autumn. Winter diets consists of fleshy fruits.	NA	NA	NA	NA	G5	S4B	1994	2005	733
Cedar Waxwing (<i>Bombusilla cedrorum</i>)	Arboreal	NA	Habitats include deciduous, coniferous, and mixed woodlands; especially open forests and riparian areas of deserts and grasslands; farms, orchards, conifer plantations, and suburban gardens also popular.	Frugivore, Invertivore	Diet consists of fleshy fruits and insects. Feeds opportunistically on small fruits, in spring and summer also various insects. May consume maple tree sap and flower petals. Apparently cannot maintain positive energy balance when feeding solely on high-sucrose fruits.	Migratory	NA	33 g	NA	G5	S5B	1992	2006	61

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Chestnut-backed Chickadee (<i>Poecile rufescens</i>)	Arboreal	Arboreal	humid coastal and interior forests from southeastern Alaska to southern California. Year-round resident throughout its range. Occurs within the densest coniferous forests, or along edges, where temperature is even and there is considerable shade. Nests in tree cavities and readily colonizes available nest boxes.	Invertivore	Insects and arthropods make up approximately 65% of the diet. Seeds and plant material make up the rest. Eats mainly insects gleaned from twigs, branches, and trunks of trees and shrubs; in the breeding season, forages often on outer foliage (needles, leaves, or buds); also eats spiders, some fruit, conifer seeds	Non-Migratory	NA	10 g	NA	G5	S4	1991	2005	119
Chestnut-sided Warbler (<i>Dendroica pensylvanica</i>)	Arboreal	Shrub	Nesting in shrubby habitat close to the ground, sometimes deciduous trees. In new, second-growth thickets of alder and other deciduous bushes growing in scrubby clearings and brushy areas or along the margins of streams, in orchards, pasturelands, forest edges, cut-over forests, roadsides, in open deciduous woodlands and in powerline corridors. Becomes most common in deciduous second growth or large forest clearings. Avoids deep woods.	Invertivore	Eats primarily the larvae and some adults of Lepidoptera and Diptera, some spiders, and some seeds and fruit as well. Usually forages alone. Gleans the undersurfaces of leaves at the low to medium levels in shrubs and the lower branches of small trees, but may feed in the upper canopy	Migratory	NA	10 g	NA	G5	SNA	1972	1993	2
Chipping Sparrow (<i>Spizella passerina</i>)	Ground	Arboreal	Prefers open woodlands, the borders of natural forest openings, edges of rivers and lakes, and brushy, weedy fields. It has a preference for nesting in open glades of coniferous forests, and for foraging in brushy open areas making it suited to human-modified habitats. Nests in a wide variety of trees and shrubs; has a distinct preference for conifers. Nest is a loosely woven cup.	Herbivore	Feeds primarily on seeds of grasses and various annual plants, infrequently supplementing this diet with small fruits. Adds insects and other invertebrates when breeding. Mainly forages on the ground, but also in foliage.	Migratory	NA	NA	Territory sizes of 1.1 to 1.8 acres	G5	S5B	1989	2006	969
Cinnamon Teal (<i>Anas cyanoptera</i>)	Riparian	Riparian	Prefers wetlands including large marsh systems, natural basins, reservoirs, sluggish streams, ditches, and stock ponds. Well-developed basins with emergent vegetation common habitat.	Omnivore	Seeds and aquatic vegetation, aquatic and semi-terrestrial insects, snails, and zooplankton. Feeds on aquatic plants in shallow water areas; especially on rush seeds, pondweed seeds and leaves, and salt grass seeds. Also eats small amounts of animal food especially insects and mollusks	Migratory	NA	408 g	NA	G5	S5B	1991	1993	3
Clark's Nutcracker (<i>Nucifraga columbiana</i>)	Arboreal	Arboreal	Found in close association with ponderosa pine, Douglas fir, and white-bark pine. Usually nests at elevations between 1800 and 2500 m. Nests on outer end of branch of a conifer, 2-45 m above ground.	Grainivore	Fresh and stored pine seeds. Also eats insects, acorns, berries, snails, carrion; sometimes eats eggs and young of small birds.	Non Migratory	NA	141 g	Foraging 0.8 to 2.4 km from nest, summer home range of 1500 ha (4.4 km in diameter). Year-round home ranges are much larger: 15,000 ha in areas of good food	G5	S5	1991	2005	130
Clay-colored Sparrow (<i>Spizella pallida</i>)	Ground	NA	Prefers open shrubland, thickets along edges of waterways, second-growth areas, and forest edges and burns	Omnivore	Feeds on a wide variety of seeds; during the summer eats insects. Forages on or near the ground. When breeding, feeds in area separate from nesting territory	Migratory	NA	NA	Nesting territories about 0.1 to 0.5 ha and 0.04-0.1 ha.	G5	S4B	1995	2004	24
Cliff Swallow (<i>Petrochelidon pyrrhonota</i>)	Aerial	Cliffs/Eaves	Open to semiwooded habitat, cliffs, canyons, farms; near meadows, marshes, and water. Builds bottle shaped mud nest in colonies on cliffs, eaves of buildings, under bridges, etc. Prefers sites with overhang.	Aerial Invertivore	Flying insects at all times of the year. Insects taken reflect local availability.	Migratory	NA	22 g	Forages usually within 0.5 km of colony	G5	S5B	1992	2005	13
Common Goldeneye (<i>Bucephala clangula</i>)	Riparian	Riparian	Breeding birds usually are found in forested wetland habitats	Aquatic Invertivore	During breeding season, primarily insectivorous and prefers lakes (often fishless) with abundant aquatic invertebrates. Fish, crustaceans, and mollusks become a more important part of the diet in winter.	Migratory	NA	1000 g	NA	G5	S5	1977	2006	10
Common Merganser (<i>Mergus merganser</i>)	Riparian	Riparian	Occur on large lakes and large rivers. During migration, most birds are on lakes	Piscivore	Eats primarily small fish, but will also eat insects, mollusks, crustaceans, worms, frogs, small mammals, birds, and plants	Migratory	Breeds at end of 2nd yr	1709 g	NA	G5	S5B	1977	2000	21
Common Nighthawk (<i>Chordeiles minor</i>)	Aerial	NA	Coastal sand dunes and beaches, woodland clearings, prairies and plains, and flat gravel rooftops of city buildings. During times of migration, habitat includes farmlands, river valleys, marshes, and coastal dunes.	Invertivore	Diet consists solely of flying insects	Migratory	NA	64 g	NA	G5	S5B	1992	2006	39

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Global Rank	State Rank	Observations in Lincoln, Co.,		
	Foraging	Nesting										Oldest	Most Recent	Number
Common Raven (<i>Corvus corax</i>)	Ground	NA	Broad range of habitats: boreal, conifer, and deciduous forests; tundra; prairies and grasslands; isolated settlements, towns, and cities; deserts; sea coasts and islands; agricultural fields; Arctic ice floes; and the highest mountains. It is one of the most widespread naturally occurring birds in the world.	Omnivore	Diverse diet includes arthropods (even scorpions), amphibians, reptiles, birds (adults, chicks, and eggs), small mammals, carrion, grains, buds, and berries.	Non Migratory	NA	689-1,625 g	Home range size of breeding birds reported at 0.2-4.4, 6.6, 9.4 and 40.5 sq km.	G5	S5	1991	2006	592
Common Redpoll (<i>Carduelis flammea</i>)	Ground/Trees	Arboreal	Open subarctic, largely coniferous forest and scrub, on dry, rocky, or damp substrates; level or steeply sloped; avoids dense forest; occurs on tundra and above timberline only where shrubby deciduous and sometimes coniferous vegetation occurs in hollows and sheltered places. Nests are built on loose foundation of small twigs laid across adjacent branches out from trunk of small spruce or in crotch of alder or willow. Forages in trees or on the ground.	Granivore, Invertivore	Very small seeds and other plant material throughout the year. Also arthropods, particularly in summer when feeding young	Migratory	NA	13 g	move up to 20 km while foraging	G5	SSN	1990	1990	3
Common Yellowthroat (<i>Geothlypis trichas</i>)	Ground	Ground	Occupies thick vegetation in wide range of habitats from wetlands to prairie to pine forest. Nests just above ground or over water, in weeds, reeds, cattails, tules, grass tussocks, brier bushes, and similar situations; often at base of shrub or sapling, sometimes higher in weeds or shrubs up to about 1 m.	Invertivore	Eats various small invertebrates obtained among low plants	Migratory	NA	10 g	NA	G5	SSB	1992	2006	37
Cooper's Hawk (<i>Accipiter cooperii</i>)	NA	Arboreal	Nest in dense deciduous and coniferous forest cover, often in draws or riparian areas. They hunt in these areas or in adjacent open country	Carnivore	Small to medium-sized birds comprise most of the diet of Cooper's hawks, although they also eat small mammals	Migratory	NA	529 g	3.2 km from nest	G5	S4B	1991	2005	11
Cordilleran Flycatcher (<i>Empidonax occidentalis</i>)	Aerial/ Arboreal	Ground/Arboreal	Coolness, shade, and nest sites" are requisites, and this species, from Alberta to n. Mexico, "invariably associated with water courses, and thus openings, in the timber. Has been known to nest in rocky outcroppings near water, in natural nest cavities in live trees (quaking aspen, Douglas fir), tree stumps, and about mountain cabins.	Invertivore	Feeds almost exclusively on insects caught in the air or gleaned from foliage of trees and shrubs.	Migratory	NA	NA	NA	G5	S5	1993	2004	22
Dark-eyed Junco (<i>Junco hyemalis</i>)	Ground	Ground-Cavity	Occurs across the continent from northern Alaska south to northern Mexico. Conspicuous ground-foraging flocks are often found in suburbs (especially at feeders), at edges of parks and similar landscaped areas, around farms, and along rural roadsides and stream edges. Most often in small cavity on sloping bank or rock face, under protruding rock, among roots (especially on vertical surface of root ball of large trees topple by wind), and in sloping road cut (especially if overhung by grass or other vegetation).	Omnivore	Seeds and arthropods, occasionally fruit and waste grain in agricultural fields. Most food obtained from ground and leaf litter	Migratory	NA	2 g	Territory sizes form of 1.7 to 2.6 acres	G5	SSB	1991	2006	1977
Dark-eyed Junco (Oregon) (<i>Junco hyemalis oregonus</i>)	Ground	Ground/Rock/Cavity	Occurs across the continent from northern Alaska south to northern Mexico. Conspicuous ground-foraging flocks are often found in suburbs (especially at feeders), at edges of parks and similar landscaped areas, around farms, and along rural roadsides and stream edges. Nest site highly variable. Most often in small cavity on sloping bank or rock face, under protruding rock, among roots (especially on vertical surface of root ball of large trees topple by wind) and in sloping road cut (especially if overhung by grass or other vegetation)	Omnivore	Seeds and arthropods; occasionally fruit and waste grain in agricultural fields. Most food obtained from ground and leaf litter	NA	NA	NA	NA	G5T5	SNR	1994	2000	11
Downy Woodpecker (<i>Picoides pubescens</i>)	Arboreal	Arboreal	Open riparian and deciduous woodlands throughout its entire range. Also use wooden human-made structures in urban areas. Nests mostly in hole dug by both sexes in dead stub of tree, also in live tree (especially dead part), fenceposts, 1-15 m above ground.	Invertivore, Frugivore	Insects, including adults, larvae, pupae, and eggs, obtained from bark of trees; also eats berries and nuts	Non Migratory	NA	27 g	NA	G5	S5	1991	2004	43
Dusky Flycatcher (<i>Empidonax oberholseri</i>)	Aerial	Shrub	Open coniferous forest, mountain chaparral, aspen groves, streamside willow thickets and brushy open areas. In MT, Nests were in small bush crotches; the average nest height was 5 feet	Aerial Invertivore	aerial forager - a sit and wait predator. It eats flying insects, occasionally pounces on prey on the ground	Migratory	NA	10 g	NA	G5	SSB	1993	2005	316
Dusky Crouse (<i>Dendragapus obscurus</i>)	Ground	NA	Winter at high elevations in conifer stands. In early spring, they descend to lower altitudes, where they prefer forest edges and openings	Omnivore	In winter they eat mainly conifer needles. In summer they eat a mixed diet of insects, green plants and berries. The young eat mainly insects	Altitudinal	NA	1188 g	Brood movement in summer is generally less than 0.5 mile	G5	S5	1977	2006	21
Eared Grebe (<i>Podiceps nigricollis</i>)	Riparian	Riparian	Shallow lakes and ponds with vegetation and macro invertebrate communities rarely on ponds with fish. They prefer saline habitats at all seasons, allowing them to escape fish predators and have an abundant of invertebrates.	Aquatic Invertivore	large variety of aquatic prey, mainly invertebrates, small crustaceans, insects, and less often small fish, mollusks, amphibians.	Migratory	NA	297 g	NA	G5	SSB	1993	1995	4

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Eastern Kingbird (<i>Tyrannus tyrannus</i>)	Aerial	NA	Open environments along forest edges and fields. Also orchards and scattered shrubs and trees favorable.	Aerial Invertivore	Eats mainly insects obtained by flycatching from perch; also eats seeds and small fruits, and may pick food from ground or water surface	Migratory	NA	40 g	NA	G5	S5B	1991	2006	13
European Starling (<i>Sturnus vulgaris</i>)	Ground	Ground/Arboreal	Exotic species. Non-Native. Owing to their close association with man and behavioral plasticity, starling inhabit a wide variety of areas if a few crucial needs are met. They forage in open country on short, mown, or grazed fields abundantly available in urban as well as agricultural areas. These areas also provide the necessary food resources, nesting cavities, and water. Nests can be found virtually anywhere a cavity can be found. Preferred sites include cavity-like openings in buildings, nest-boxes, cavities usurped from woodpeckers, and natural cavities in trees. Found occasionally without a cavity in dense vegetation in trees or on the ground.	Omnivore	Extremely diverse diet that varies geographically, with the age of individuals, and with season. Generally will eat invertebrates when available, fruits and berries, grains and certain seeds during other times of the year. Most foraging time is spent in open areas with short vegetation.	Non Migratory	NA	85 g	NA	G5	SNA	1991	2006	18
Evening Grosbeak (<i>Coccothraustes vespertinus</i>)	Arboreal	Arboreal	Common in mixed-conifer and spruce-fir forests, less common in pine-oak, punon, Cascadian, ponderosa pine and aspen forests. Less closely tied to coniferous tree species than other carduelines-also uses deciduous species for nesting and food. Nests primarily in trees but also in shrubs, a spare structure, shaped like flattened saucer.	Omnivore	Invertebrates, especially spruce budworm and other larvae; wide variety of small fruits and seeds, especially maples	Migratory	NA	60 g	NA	G5	S5	1992	2003	154
Flammulated Owl (<i>Otus flammecolus</i>)	Ground	Arboreal	Associated with mature and old-growth xeric ponderosa pine/Douglas-fir stands and in landscapes with higher proportions of suitable forest and forest with low to moderate canopy closure. They are absent from warm and humid pine forests and mesic ponderosa pine/Douglas-fir. Most often nests in an abandoned tree cavity made by Pileated Woodpecker, flicker, sapsucker or other large primary cavity nester, at heights from 1 to 16 meters	Invertivore	Hunt at night and eat nocturnal arthropods. Feeds on various insects (e.g., moths, beetles, grasshoppers, crickets, caterpillars;	Migratory	NA	47 g	Territory size about 5.2 sq km	G4	S3B	1992	2005	32
Fox Sparrow (<i>Passerella iliaca</i>)	Ground	NA	Areas of thick cover, usually around forest edges and brushy woodland edges. Also found in grown-up fields, cut-over woodland, and scrubby woods.	Omnivore	Forages on the ground for seeds (e.g., smartweed, ragweed). Also eats berries (e.g., blueberries, elderberries) grapes and other fruits. Diet consists mainly of insects. Other food sources include seeds, fruit and plant matter.	Migratory	NA	30 g	NA	G5	S5B	1991	2005	192
Gadwall (<i>Anas strepera</i>)	Riparian	Riparian	Nest density was highest in saline lowlands, followed by dense nesting cover panspots, and silty/ shallow clay. Nest success was highest in saline lowlands then clay, panspots, silty sites and dense cover	Herbivore	Mainly of submerged aquatic vegetation, seeds and aquatic invertebrates.	Migratory	NA	990 g	NA	G5	S5B	1995	2006	4
Golden Eagle (<i>Aquila chrysaetus</i>)	Carnivore	Arboreal/Climbs	Nest on cliffs and in large trees (occasionally on power poles), and hunt over prairie and open woodlands.	Carnivore	Primarily jackrabbits, ground squirrels, and carrion (dead animals). They occasionally prey on deer and antelope (mostly fawns), waterfowl, grouse, weasels, skunks, and other animals.	Migratory	NA	4,692 g	Territory size in several areas of the western U.S. averaged 57-142 sq km	G5	S4	1997	2000	4
Golden-crowned Kinglet (<i>Regulus satrapa</i>)	Arboreal	Arboreal	Nests in forests with closed or open canopies, edges of clearings, or near water	Invertivore	Feeds primarily on insects and their eggs (e.g., bark beetles, scale insects, aphids). Also drinks tree sap and eats some fruit and seeds (rare). Young are fed various insects and other small arthropods and sometimes small snails	Migratory	NA	6 g	Territory size in northern Minnesota was 2.1-6.2 acres (mean 4.1 acres)	G5	S5	1991	2005	818
Gray Catbird (<i>Dumetella carolinensis</i>)	Shrub	Shrub	Throughout range found in dense shrubs or vine tangles; most abundant in shrub-sapling-stage successional habitats. Also found in forest edges and clearings, roadsides, fencerows, abandoned farmland and home sites, pine plantations, streamsides, and some residential areas. Uncommon in areas dominated by conifers.	Omnivore	Main foods taken include insects and small fruits	Migratory	NA	37 g	NA	G5	S5B	1994	2005	16

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Gray Jay (<i>Perisoreus canadensis</i>)	Arboreal	Arboreal	A widespread resident of North America's boreal and sub-alpine coniferous forests. Nests of low to moderate height, often 1 or 2 trees north of north edge of open bog, road allowance, or other break in the forest.	Omnivore	Arthropods, berries, carrion, nestling birds, fungi. Copious sticky saliva from enlarged salivary glands is used to fasten food items in trees, food that is used extensively by pairs throughout the winter and even during other times of the year.	Non Migratory	NA	71 g	NA	G5	S5	1991	2006	328
Gray Partridge (<i>Perdix perdix</i>)	Ground	NA	Exotic species. Non-native. Habitat consists of a mixture of cultivated and noncultivated land; grasslands interspersed with wheat fields, weed patches, and brushy cover. Optimum conditions are a cool, moderately dry climate and a mixture of cultivated and noncultivated land. Grain fields and winter wheat stubble are also used. Field edges provide escape and winter cover.	Grainivore	Waste grain is a staple fall and winter food. Weed seeds and insects are summer food. Feeds primarily on seeds of wheat, corn, barley, oats, smartweeds, lambs' quarters, crabgrass, etc. Also eats leaves of clover, alfalfa, bluegrass, dandelion, etc. Chicks feed on insects for first few weeks of life.	Non Migratory	NA	398 g	In New York, home range size was 82-672 ha, did not differ by season	G5	SNA			2
Great Blue Heron (<i>Ardea herodias</i>)	Riparian	Riparian	Nested primarily in cottonwoods in riparian zones, and also in drier, coniferous sites. Nesting trees are the largest available. Active colonies are farther from rivers than inactive colonies. The number of nests in the colony corresponded to the distance from roads.	Piscivore	Feeds mostly in slow moving or calm freshwater. Eats mostly fish but also amphibians, invertebrates, reptiles, mammals, and birds.	Migratory	NA	2,576	NA	G5	S3S4	1981	2006	36
Great Gray Owl (<i>Strix nebulosa</i>)	Carnivore	Dead Trees	Use lodgepole pine/Douglas-fir in Montana. Habitat is dense coniferous and hardwood forest, especially pine, spruce, paper birch, poplar, and second-growth, especially near water. They forage in wet meadows, boreal forests and spruce-tamarack bogs in the far north, and coniferous forest and meadows in mountainous areas. Nest in the tops of large broken-off tree trunks (especially in the south), in old nests of other large birds (e.g., hawk nest) (especially in the north), or in debris platforms from dwarf mistletoe, frequently near bogs or clearings.	Carnivore	Small mammals, especially rodents (i.e. voles) dominate prey over most of the range. Pocket gophers also dominate the diet of Great Gray Owls in North America. They usually forage in open areas where scattered trees or forest margins provide suitable sites for visual searching.	Migratory	NA	1,298	NA	G5	S3	2000	2000	5
Great Horned Owl (<i>Bubo virginianus</i>)	Carnivore	Arboreal/Climbs/Cavity	Occurs from river bottoms to timberline throughout the state. Nests in stick nests made by other birds, broken-topped snags, hollow trees, and cliff cavities.	Carnivore	small to medium-sized mammals and birds.	Non Migratory	NA	1,769	Home range size varies seasonally and geographically. Breeding territories in southwest Yukon 230-883 ha, averaging 483 ha; nonterritorial floaters averaged 725 ha	G5	S5	1992	2005	10
Green-winged Teal (<i>Anas crecca</i>)	Riparian	Riparian	Highest densities in wooded ponds of deciduous parklands, with additional breeding in boreal forests, arctic deltas, and mixed prairie regions. Often inhabits grasslands or sedge meadows with brush thickets or woodlands next to a marsh or pond. Often inhabits beaver ponds in wooded areas. Ground nester. Nests typically in sedge meadows, grasslands, brush thickets, or woods near a pond. Eggs are elliptical to subelliptical.	Omnivore	Broad diet. Seeds of sedges, grasses, and aquatic vegetation; aquatic insects and larvae, molluscs, crustaceans	Migratory	NA	364 g	NA	G5	S5B	1986	2005	6
Hairy Woodpecker (<i>Picoides villosus</i>)	Arboreal	Arboreal - Cavity	Primarily a forest bird; widely distributed in regions where mature woodlands prevalent. Also occurs in small woodlots, wooded parks, cemeteries, shaded residential areas, and other urban areas with mature shade trees, but often scarce within these habitats. Cavity nester. In western North America, more often in large dead stubs or in some areas in aspen with fungal decay.	Omnivore	Tree surface and subsurface arthropods and a diversity of fruits and seeds. Readily comes to feeders	Migratory	NA	70 g	Territory size 0.6-1.5 hectares; varies with habitat quality. In central Ontario, breeding territories averaged 2.8 hectares, range 2.4 to 3.2 ha	G5	S5	1991	2005	237
Hammond's Flycatcher (<i>Empidonax hammondi</i>)	Aerial	Arboreal	Inhabits cool forest and woodland, breeding primarily in dense fir, mature coniferous or mixed forests to near timberline. Nests were saddled on limbs of mature conifers, 10.5 to 40 feet high	Aerial Invertivore	Diet consists of insects. The Hammond's Flycatcher is primarily an aerial forager, capturing most of its insect diet on the wing. On occasion it may forage from leaf surfaces or from the ground	Migratory	NA	10 g	Territory sizes of 1.6 to 3.2 acres in Douglas fir or lodgepole forests in western Montana	G5	S4B	1992	2006	355
Harlequin Duck (<i>Histrionicus histrionicus</i>)	Riparian	Riparian	Inhabit fast moving, low gradient, clear mountain streams. Overstory in Montana does not appear to affect habitat use	Aquatic Invertivore	95% of the material in droppings in Grand Teton National Park consisted of Stoneflies, Mayflies, and Caddisflies	Migratory	NA	687 g	NA	G4	S2B	1972	2005	76

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	Habitat Group		Observations in Lincoln, Co.,											
Common Name (Genus/species)	Foraging	Nesting	General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Global Rank	State Rank	Oldest	Most Recent	Number
Harris's Sparrow (<i>Zonotrichia querula</i>)	Ground	Ground	Frequents streams, hedgerows, shelterbelts, and brushy ravines dominated by deciduous trees and shrubs. Feeds primarily on the ground, scratching and kicking away ground litter with its feet; forages less frequently among branches of trees. Nests are located on the ground, typically under a shrub that is on top of, or next to, a hummock. May also be located beneath rock or turf overhangs. In Northwest Territories, most nests are concealed amid dwarf birch, alder, spruce, and Labrador tea. Nest entrances are often oriented to the southeast, opposite the direction of prevailing storms	Omnivore	Diet consists of seeds, fruits, arthropods, and young conifer needles.	Migratory	longest 11yr 8mo	39 g	Territories averaged 2 hectares, but birds foraged up to 500 meters outside territories	G5	SNA			2
Hermit Thrush (<i>Catharus guttatus</i>)	Ground	NA	Species prefers interior forest edges such as margins of ponds and edges of meadows in forested areas	Omnivore	During breeding diet consists mostly of animal matter, especially insects and other small invertebrates. During migration and winter, diet supplemented by wide variety of fruits. Forages from ground.	Non Migratory	NA	31 g	Territory sizes of 5.1 to 5.6 acres in Douglas fir or lodgepole pine forests in western MT	G5	S5B	1991	2005	355
Herring Gull (<i>Larus argentatus</i>)	Riparian	Riparian	Mainly islands and areas around water. Sometimes found in rocky or sandy cliffs; occasionally on rooftops near water.	Scavenger	Diet consists of marine invertebrates, fishes, insects, other seabirds, and adults, eggs, and young of congeners. Feeds opportunistically mostly on various animals and garbage. Often a scavenger around bays and harbors.	Migratory	Adult plumage in 4 yr	1226 g	NA	G5	SNA	1995	1995	3
Hoary Redpoll (<i>Carduelis hornemanni</i>)	Ground	Ground	Open forest and scrub, extending farther onto tundra than Common Redpoll, but still requiring shrub, at least in sheltered hollows; substrate damp or dry. During migration and in winter, often joins with Common Redpolls. Occurs in open woodland and shrub, along field edges and weed patches and in towns and villages. Nest sites similar to Common Redpoll but may be closer to water, often over shallow water; in willows, alder, spruce, tamarack, birch. Where otherwise suitable sites unavailable, nests in cavities in driftwood.	Herbivore	Small seeds of various trees, shrubs, weeds and grasses, along with other plant parts, supplemented with invertebrates in summer	Migratory	NA	13 g	NA	G5	SNA			2
Hooded Merganser (<i>Lopholytes cucullatus</i>)	Riparian	Riparian	Hooded Mergansers are generally found in river areas bounded by woods and supporting good fish populations associated with clear water	Aquatic Invertivore	Main foods taken are primarily aquatic insects, fish, and crustaceans (particularly crayfish).	Migratory	First breed at 2 yr	680 g	NA	G5	S4B	2006	2006	3
Horned Grebe (<i>Podiceps auritus</i>)	Riparian	Riparian	Breeding Range is on shallow freshwater ponds and marshes with beds of emergent vegetation, especially sedges, rushes and cattails. In spring and fall the Horned Grebe is mainly on large sized bodies of water, including rivers and small lakes. The floating nest is usually concealed in the vegetation.	Aquatic Invertivore	Aquatic arthropods in the summer, & fish and crustaceans in winter, especially amphipods, crayfish, and polychaetes.	Migratory	NA	453 g	NA	G5	S4			2
Horned Lark (<i>Eremophila alpestris</i>)	Ground	Ground - Cavity	Open, generally barren country; avoids forests. Prefers bare ground to grasses taller than a few cm. May nest on marshy soil but generally prefers, throughout its range, bare ground such as plowed or fall-planted fields. Digs nest cavity or may use a natural depression. Food obtained from ground.	Granivore	In winter, mostly seeds. During the breeding season, adults eat mostly seeds but feed insects to their young. Adults take more insects during the spring and fall than at other times, perhaps to compensate for the energetic demands of breeding and molt	Migratory	NA	32 g	Territory size varies with habitat and population density; ranges from means of 3.5 ha in higher latitude heath, 1.6 ha in the agricultural Midwest to a range of 0.3-14 ha in Colorado shortgrass prairie	G5	S5			2
House Finch (<i>Carpodacus mexicanus</i>)	Ground	NA	A common backyard bird throughout most of the contiguous United States. In its native west, this species occupies a wide range of open or semi-open habitats from undisturbed desert to highly urbanized areas. In the east, it is rarely found far from urban or suburban areas.	Herbivore	In all seasons, 97% of diet is vegetable matter including buds, seeds, and fruits. Primary weed seeds eaten include Napa thistle, black mustard, wild mustard, Amaranth, knotweed and turkey mullen, plus some 21 additional seed varieties. In late summer it will eat fruits.	Non Migratory	NA	21 g	NA	G5	S5	1995	1998	2
House Sparrow (<i>Passer domesticus</i>)	Ground	Arboreal	Exotic. Non-Native. Breeding habitat is mostly associated with human modified environments such as farms, and residential and urban areas. Absent from extensive woodlands, forests, grasslands, and deserts. Nest often in enclosed spaces. If they nest in trees the nest usually is a globular structure with a side entrance and may share a wall with a neighboring nest.	Granivore	Have been known to eat livestock feed. Grains, weed seeds, relatively few insects. Urban birds eat commercial birdseed.	Non Migratory	NA	28 g	NA	G5	SNA	1995	2005	4

Attachment A-2. Bird Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,					
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number	
House Wren (<i>Troglodytes aedon</i>)	Ground/Shrub	Cavity	Affinity for open, shrubby woodlands, mimicked so well by small town and suburban backyards and city parks; has a preference for human-made "bird houses". Nests usually in cavities (natural, abandoned woodpecker holes, bird boxes, and within various human artifacts). Male starts several nests, female finishes nest.	Invertivore	Feeds primarily on small, terrestrial invertebrates	Migratory	NA	11 g	NA	G5	S5B	1992	1998	16	
Killdeer (<i>Charadrius vociferus</i>)	Ground	Ground	Frequents open areas, especially sandbars, mudflats, heavily grazed pastures, and such human-modified habitats as cultivated fields, athletic fields, airports, golf courses, graveled or broken-asphalt parking lots, and graveled rooftops	Invertivore	Main foods taken include terrestrial invertebrates, especially earthworms, grasshoppers, beetles, and snails; infrequently small vertebrates and seeds	Migratory	NA	101 g	NA	G5	S5B	1992	2007	17	
Lark Sparrow (<i>Chondestes grammacus</i>)	Ground	Ground/Arboreal/Cavity	Widespread in open habitats such as shrub-steppe, pinon-juniper edges, grasslands, roadsides, farmlands, and pastures. Nests on bare ground, in hollow depression, or in shrub or tree up to 2.75 m from ground. May use unusual nest sites such as a natural cavity of a dead tree. Nest either on the ground or close to the ground (within 4 meters) in woody vegetation	Omnivore	Categorized as a ground-foraging omnivore during the breeding season, and a ground-gleaning granivore during the nonbreeding period. In breeding season, eats more insects than seeds. During colder periods, when insects are less readily available, seeds may be primary diet.	Migratory	NA	29 g	Territories around immediate nest site (Martin and Parrish 2000), 66-248 sq. m in extent	G5	S5B	2004	2004	2	
Lazuli Bunting (<i>Passerina amoena</i>)	Ground	Arboreal/Shrub	Arid brushy areas in canyons, riparian thickets, chaparral and open woodland; in migration and winter also in open grassy and weedy areas. Nests in small trees, shrubs, or vines, 0.3-3 m above ground	Omnivore	Feeds on insects (grasshopper, caterpillars, beetles, ants, etc) and seeds (wild oats, canary grass, needlegrass, etc.)	Migratory	NA	16 g	NA	G5	S5B	1991	2006	35	
Least Flycatcher (<i>Empidonax minimus</i>)	Aerial	NA	Semi-open, second-growth, and mature deciduous and mixed woods; occasionally conifer groves, burns, swamp and bog edges, orchards, and shrubby fields. Often found near open spaces such as forest clearings and edges, water, roads, and cottage clearings. Nest is a neat compact cup, generally not protected or only partially protected by surrounding vegetation.	Aerial Invertivore	Feeds almost exclusively on insects caught by hawking from the air or gleaned from foliage of trees and shrubs. Fruits and seeds taken occasionally.	Migratory	NA	10 g	NA	G5	S5B	1994	1998	13	
Lesser Scaup (<i>Aythya affinis</i>)	Riparian	Ground	In the Bozeman area, habitat is generally restricted to lakes and ponds. Throughout fall and winter this species forms large flocks on rivers, lakes, and large wetlands. Pairs and broods typically associated with fresh to moderately brackish, seasonal and semipermanent wetlands and lakes with emergent vegetation such as bulrush, cattail and river bulrush. builds nest on the ground near or over water, as well as in uplands	Aquatic Invertivore	Mainly aquatic invertebrates such as insects, crustaceans, and mollusks. Seeds and vegetative parts of aquatic plants are important in certain areas	Migratory	NA	850 g	NA	G5	S5B	1993	1995	4	
Lewis's Woodpecker (<i>Melanerpes lewis</i>)	Aerial	Arboreal	Occur in river bottom woods and forest edge habitats. Nest in a natural cavity, abandoned northern flicker hole, or previously used cavity, 1-52 meters above ground. Sometimes will excavate a new cavity in a soft snag (standing dead tree), dead branch of a living tree, or rotting utility pole	Aerial Invertivore	Adult emergent insects (e.g., ants, beetles, flies, grasshoppers, tent caterpillars, mayflies) in summer and ripe fruit and nuts in fall and winter. They are opportunistic and may respond to insect outbreaks and grasshopper swarms by increasing breeding densities.	Migratory	NA	116 g	NA	G4	S2B	1991	1995	8	
Lincoln's Sparrow (<i>Melospiza lincolni</i>)	Ground	Ground	Found mainly in boggy, willow, sedge, and moss-dominated habitats, particularly where shrub cover is dense. At lower elevations, also prefers mesic willow shrubs, but can be found in mixed deciduous wood groves such as aspen and cottonwoods. Nests on the ground, most often inside a low willow shrub or mountain birch that also contains fairly dense sedge cover.	Omnivore	Winter: small seeds, terrestrial invertebrates when available. Occasionally uses feeders. Breeding season: mostly arthropods, also small seeds when available. Forages on ground under grass and brush	Migratory	NA	17 g	Breeding territory about 0.4 ha	G5	S5B	1992	1998	10	
Long-eared Owl (<i>Asio otus</i>)	Carnivore	Arboreal	Most often observed in hedgerows, woody draws, and juniper thickets, although they do occur within the forest edge. They are predominantly open-country hunters; however, they are seldom seen because of their nocturnal habits. Nests in a stick nest built by other raptors, magpies, crows, or ravens	Carnivore	Depends heavily on small rodents.	Migratory	NA	279 g	in Siberia, nesting pairs remained in an area about 100-300 meters in diameter	G5	S5	2003	2003	3	
MacGillivray's Warbler (<i>Oporornis tolmiei</i>)	Riparian-Ground	Shrub	Commonly found in riparian habitat and clearcuts of northern coniferous forests along the Rocky Mountains. Forages along streams or in dense second growth. Commonly found in deciduous, shrubby riparian habitats. Usually nests low, 0.6-1.5 meters above ground, in bushes, saplings, clump of ferns, etc.	Invertivore	Main food is insects. Feeds on or just above the ground.	Migratory	NA	10 g	NA	G5	S5B	1991	2005	488	

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Mallard (<i>Anas platyrhynchos</i>)	Riparian	Riparian	In North America, the Mallard is the most abundant duck species. Its success in the wild reflects its adaptability to varied habitats, its hardiness in cold climates, and tolerance of human activities. Usual nest site is in uplands close to water. Nests in wide variety of situations with dense cover, including grasslands, marshes, bogs, riverine floodplains, dikes, roadside ditches, pastures, cropland, shrubland, fence lines, rock piles, forests, and fragments of cover around farmsteads	Omnivore	Very flexible in food choice, diet composition depends on stage of annual cycle, hydrological conditions, invertebrate behavior, and crop-harvesting schedule	Migratory	NA	1,082 g	NA	G5	S5	1977	2006	34
Marsh Wren (<i>Cistothorus palustris</i>)	Riparian	Riparian	Freshwater and brackish marshes in cattails, tule, bulrush, and reeds. Nests in marsh vegetation; female finishes one of several nests started by male; male may continue to build nests even after female begins incubation. Nesting success may be greatest in marshes with relatively dense vegetation and deep water	Aquatic Invertivore	Eats mainly insects and other invertebrates	Migratory	NA	12 g	NA	G5	S5B	1991	2006	7
Merlin (<i>Falco columbarius</i>)	Carnivore	Arboreal	Breeding pairs in eastern Montana usually use sparse conifer stands adjacent to prairie habitats, but sometimes use shelterbelts and river bottom forests. In western Montana, they use open stands of conifers and river bottom forests. Merlins sometimes nest in urban areas	Carnivore	Bulk of diet usually consists of small to medium-sized birds, often flocking species. Large flying insects (e.g., dragonflies) may be important for young learning to hunt. Also eats toads, reptiles, and mammals	Migratory	NA	244 g	NA	G5	S4			3
Mountain Bluebird (<i>Sialia sialis</i>)	Ground	Arboreal	Subalpine meadows, grasslands, shrub-steppe, savanna, and pinyon-juniper woodland; in south usually at elevations above 1500 m. In winter and migration also inhabits desert, brushy areas and agricultural lands. Nests are built in natural tree cavities, or abandoned woodpecker holes. May also use bird box, old swallow's nest, rock crevice, or old mammal burrow.	Invertivore/Omnivore	Insectivorous. Feeds on beetles, ants, bees, wasps, caterpillars, grasshoppers, etc. Also consumes some berries and grapes seasonally. Hovers and drops to ground while foraging or darts out from a low perch to catch prey.	Migratory	NA	28 g	NA	G5	S5B	1991	2006	147
Mountain Chickadee (<i>Parus gambeli</i>)	Shrub	Ground/Arboreal	Year round resident of montane coniferous forests of west North America, primarily in areas dominated by pine, spruce-fir and pinon juniper. Occurs in mixed coniferous-deciduous forests. Nests in a natural tree cavity, woodpecker hole, hole in the ground, or under a rock in a bank. Nest height usually is low, but may be up to 25 m.	Invertivore	Insects during warm seasons augmented with spiders. Conifer seeds during cool seasons.	Non Migratory	NA	12 g	Mean territory size 1.5 ha in Arizona;	G5	S5	1991	2006	875
Mourning Dove (<i>Zenaidura macroura</i>)	Ground	Ground	tremendous adaptability. Generally shuns deep woods or extensive forest and selects more open woodlands and edges between forest and prairie biomes for nesting. Human alteration of original vegetations is generally beneficial for this species, with creation of opening in extensive forest and plowing of grasslands for cereal-grain production. Additional habitat created with planting of trees and shrubs in cities, towns, and suburbs. Nests primarily at woodland or grassland edge, usually in trees but readily on ground in absence of suitable trees or shrubs.	Granivore	Mostly seeds (99%). Insignificant amounts of animal matter and green forage may be acquired incidentally. Principal food items vary by region and immediate locale. Feeds almost entirely on ground	Migratory	NA	123 g	Average home range in Missouri was 3200 ha, but most activity was within 1.6 kilometers	G5	S5B	1993	2006	24
Myrtle Warbler (<i>Dendroica coronata auduboni</i>)	NA	NA	NA	NA	NA	NA	NA	NA	NA	G5	S5B	1994	2000	10
Nashville Warbler (<i>Vermivora ruficapilla</i>)	Ground/Arboreal	Ground	Forest-bordered bogs, second growth, open deciduous and coniferous woodland, forest edge and undergrowth, cutover or burned areas; in migration and winter in various woodland, scrub, and thicket habitats. Nests on ground at base of bush, small tree, sapling, or clump of grass, or in hollow in moss.	Invertivore	Eats insects; forages from ground to treetop, but mainly low in trees and thickets at edge of forest	Migratory	NA	9 g	NA	G5	S5B	1991	2005	58
Northern Flicker (<i>Colaptes auratus</i>)	Ground	Arboreal	A common, primarily ground-foraging woodpecker that occurs in most wooded regions of North America. Prefers forest edge and open woodlands. Yellow-shafted Flickers reported nesting in most tree species in the wide range of woodlands it inhabits. Red-shafted Flickers are particularly common in quaking aspen stands and cottonwoods in riparian woodlands and in burned woodlands. Cavities excavated by flickers are used by many species of secondary cavity users.	Invertivore	Insects, primarily ants; fruits and seeds, especially in winter. Feeds on the ground or catches insects in the air.	Migratory	NA	142 g	NA	G5	S5	1991	2006	572

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Northern Flicker (Red-shafted) (<i>Colaptes auratus cafer</i>)	Ground	Arboreal	A common, primarily ground-foraging woodpecker that occurs in most wooded regions of North America. Prefers forest edge and open woodlands. Yellow-shafted Flickers reported nesting in most tree species in the wide range of woodlands it inhabits. Red-shafted Flickers are particularly common in quaking aspen stands and cottonwoods in riparian woodlands and in burned woodlands. Cavities excavated by flickers are used by many species of secondary cavity users.	Invertivore	Insects, primarily ants; fruits and seeds, especially in winter. Feeds on the ground or catches insects in the air.	Migratory	NA	142 g	NA	G5T5	SNRB	1994	2000	11
Northern Goshawk (<i>Accipiter gentilis</i>)			Goshawks in Montana tend to nest predominately in mature large-tract conifer forests with a high canopy cover (69%), relatively steep slope (21%) and little to sparse undergrowth. Nests were constructed an average 10.9 meters above the ground and were usually located near water (232 m) or a clearing (85 m)	Carnivore	Forage during short flights alternating with brief prey searches from perches. They also hunt by flying rapidly along forest edges, across openings, and through dense vegetation. An opportunistic hunter, Northern Goshawks prey on a wide variety of vertebrates and, occasionally, insects. Prey is taken on the ground, in vegetation, or in the air.	Non Migratory	Breed at 1-2 yr	1137 g	NA	G5	S3	1924	2005	153
Northern Pintail (<i>Anas acuta</i>)	Riparian	Riparian	prefer large lakes. Breeders favor shallow wetlands interspersed throughout prairie grasslands or arctic tundra. An early fall migrant, the species arrives on wintering areas beginning in August, after wing molt, often forming large roosting and feeding flocks on open, shallow wetlands and flooded agricultural fields	Grainivore	Grain (rice, wheat, corn, barley), moist-soil and aquatic plant seeds, pond weeds, aquatic insects, crustaceans, and snails	Migratory	NA	1035 g	NA	G5	S5B	1995	2006	4
Northern Pygmy-owl (<i>Glaucidium gnoma</i>)	Carnivore		most often seen in mixed fir forests, but can be found from river bottoms to timberline.	Carnivore	Small birds, mammals, insects, and probably a few reptiles and amphibians. Small birds may be an important part of its diet.	Non Migratory	NA	73 g	NA	G5	S4	1994	2005	12
Northern Rough-winged Swallow (<i>Stelgnopteryx serripennis</i>)	Aerial	Ground	Long-distance migrant in the U.S. and Canada. Breeding populations from the lowlands and central interior of Mexico southward are generally sedentary, though they may make local elevational migrations to coastal areas in winter	Invertivore	Flys through air and catches insects (e.g., flies, wasps, bees, beetles). Swoops low over open ground or water. Occasionally may scavenge on ground.	Migratory	NA	16 g	NA	G5	S5B	1991	2006	18
Northern Saw-whet Owl (<i>Aegolius acadicus</i>)	Carnivore	Arboreal	Most common in coniferous forests; however, they can be found in deciduous trees along watercourses. Nests in woodpecker holes and possibly natural cavities.	Carnivore	Eats mainly small mammals sometimes birds and insects.	Non Migratory/Elevational	NA	91 g	NA	G5	S4	1994	2005	8
Olive-sided Flycatcher (<i>Contopus cooperi</i>)	Aerial	Ground	Generally breeds in the montane and boreal forests in the mountains of western North America, highly adapted to the dynamics of a landscape frequently altered by fire. They are more often associated with post-fire habitat than any other major habitat type, but may also be found in other forest openings (clear cuts and other disturbed forested habitat), open forests with a low percentage of canopy cover, and forest edges near natural meadows, wetlands, or canyons. Nests are placed most often in conifers (Harrison 1978, 1979), on horizontal limbs from two to 15 meters from the ground.	Invertivore	hovering or sallying forth, concentrating on prey available via aerial attack. They generally launch these aerial attacks from a high, exposed perch atop a tree or snag. Like others in the flycatching guild, this bird is a passive searcher, looking for easy to find prey, but is also an active pursuer, attacking prey difficult to capture	Migratory	NA	32 g	NA	G4	S3B	1992	2005	332
Orange-crowned Warbler (<i>Vermivora celata</i>)	Arboreal	Ground	Prefers habitats with shrubs and low vegetation, often in aspen forest or in riparian or chaparral areas which provide cover for its nest. Nests well concealed, often on or near ground or in small crevices or depression in ground/rock, along shady hillside, on slopes or steep banks, sheltered by overhanging vegetation. Also found in shrubby bushes, ferns, vines. Nest is a small open cup.	Invertivore	Gleans insects from leaves, blossoms, and the tips of boughs, but also eats some berries and fruit and is attracted to suet feeders in the winter.	Migratory	NA	9 g	NA	G5	S5B	1992	2004	608
Pileated Woodpecker (<i>Dryocopus pileatus</i>)	Arboreal	Arboreal	Late successional stages of coniferous or deciduous forest, but also younger forests that have scattered, large dead trees. Dead trees provide favored sites in which to excavate nest cavities. Only large-diameter trees have enough girth to contain nest.	Invertivore	Diet consists primarily of wood-dwelling ants and beetles that are extracted from down woody material and from standing live and dead trees. Fruit and mast of wild nuts when available.	Non-Migratory	9 years	308 g	NA	G5	S4	1991	2005	256
Pine Grosbeak (<i>Pinicola enucleator</i>)	Arboreal	NA	Open coniferous forests of north-western mountain ranges and in coastal and island rain forests of Alaska and British Columbia. Always most common in places where forest is open.	Omnivore	During most of the year 99% of diet is vegetable matter, especially buds, seeds and fruits. Feeds young a diet of mainly insects and spiders often mixed with vegetable matter	Migratory	NA	56 g	NA	G5	S5	1988	2004	59

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Pine Siskin (<i>Carduelis pinus</i>)	Ground	NA	Forests and woodlands, parks, gardens and yards in suburban areas; in migration and winter in a variety of woodland and forest habitats, partly open situations with scattered trees, open fields, pastures and savanna.	Herbivore	Forages in trees and on the ground for seeds (e.g., of alder, birches, pines, maples, thistles) and insects. Also eats flower buds of elms, drinks nectar from eucalyptus blossoms and sap from sapsucker's holes	Migratory	NA	15 g	NA	G5	S5	1991	2006	1243
Pygmy Nuthatch (<i>Sitta pygmaea</i>)	Arboreal	Arboreal	long-needled pine forests - principally ponderosa pines. Reaches its highest densities in mature pine forests little affected by logging, firewood collection, and snag removal. A cavity nester, can excavate own cavity, but will use woodpecker holes and natural cavities	Invertivore	Feeds mainly on weevils and leaf and bark beetles, but also eats pine seed. At feeders, eats suet and sunflower seeds	Non-Migratory	NA	11 g	NA	G5	S4	1993	2004	11
Red Crossbill (<i>Loxia curvirostra</i>)	Arboreal	Arboreal	Coniferous and mixed coniferous-deciduous forests; also pine savanna and pine-oak habitat. In migration and winter may also occur in deciduous forest, and more open scrubby areas. Nests in conifers, 1.5-25 m above ground, toward outer end of branch	Omnivore	Eats seeds, buds, and insects. Forages in trees; also picks up seeds from the ground.	Non-Migratory	NA	37 g	NA	G5	S5	1989	2004	692
Red-breasted Nuthatch (<i>Sitta canadensis</i>)	Arboreal	Arboreal	Prefers forests that have a strong fir and spruce component. May also breed in mixed woodland when a strong coniferous component is associated with deciduous trees such as aspen, oak and poplar. The nests are open and built up from a variety of grasses, strips of bark and pine needles.	Invertivore	Eats mainly arboreal arthropods during the breeding season and a large number of conifer seeds outside the breeding season.	Migratory	NA	10 g	NA	G5	S5	1991	2005	1724
Red-eyed Vireo (<i>Vireo olivaceus</i>)	Arboreal	NA	Breeds in deciduous and mixed deciduous-coniferous forest. Absent from sites where understory shrubs are sparse or lacking. Often found near small openings in forest canopy. Can occur in residential areas, city parks, and cemeteries where large trees grow. During spring and fall migration uses a greater variety of forested habitats than during breeding season, but still prefers deciduous woodland over conifers. Winter range finds them present in various forested habitats from sea level up to 3000 m elevation.	Invertivore	Consumes mostly insects, particularly caterpillars. During breeding season most often observed foraging in canopy vegetation. Also eats various small fruits, most frequently in late summer and fall. In winter, mostly frugivorous	Migratory	NA	17 g	NA	G5	S5B	1993	2000	25
Red-naped Sapsucker (<i>Sphyrapicus nuchalis</i>)	Arboreal	Arboreal	nesting in broken-top larch; optimum habitat is old-growth larch, particularly near wet areas. Nest cavities made in dead trees or dead portions of live trees. Pure white, moderately glossy eggs are ovate to elliptical-ovate or rounded-ovate.	Herbivore	Sap wells in the bark of woody plants and feed on sap that appears there. Often drill sap wells in the xylem of conifers and aspens. Once the temperature increase and sap begins to flow, these birds switch to phloem wells in aspen or willow, if available. Insects, also bast (inner bark), fruit, and seeds.	Migratory	NA	NA	NA	G5	S5B	1992	2006	189
Red-tailed Hawk (<i>Buteo jamaicensis</i>)	Carnivore	Arboreal/Climbs	nest in trees and on cliffs, and hunt over grasslands, open woodlands, and agricultural areas.	Carnivore	primarily ground squirrels and other small rodents, but also feed on a wide variety of other animals. Red-tailed hawks often eat snakes, including rattlesnakes	Migratory	NA	1,224 g	NA	G5	S5B	1989	2006	73
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	NA	NA	Breeds in a variety of wetland and upland habitats. Wetland habitats include freshwater marsh, saltwater marsh, and rice paddies. Upland breeding habitats commonly include sedge meadows, alfalfa fields and other crop lands and old fields. Roosts in habitats with dense cover.	Omnivore	During the nonbreeding season, diet is primarily plant matter. During breeding season, diet is primarily animal matter with some plant matter.	Migratory	NA	64 g	NA	G5	S5B	1993	2006	21
Ring-billed Gull (<i>Larus delawarensis</i>)	Riparian	Riparian	Spring and fall migration prefers fresh water (lakes, river marshes, reservoirs, irrigation and agricultural areas). Occurs inland more often than other species of gulls - near landfill sites, golf courses, farm fields. Winter range mostly on or near coast. Common around docks, wharves, harbors; scarce in pelagic waters; inland on reservoirs, lakes, ponds and streams, landfill sites, and shopping malls in large metropolitan centers.	Invertivore	fish, insects, earthworms, rodents, and grain. At Freezeout Lake, stomach contents included insects, oligochaetes, crustaceans, birds and mammals, and plant material believed to be consumed incidentally to consuming animals	Migratory	NA	566 g	NA	G5	S5B	1991	2006	5
Ring-necked Duck (<i>Aythya collaris</i>)	Riparian	Riparian	Freshwater wetlands, especially marshes, fens, and bogs that are generally shallow with fringes of flooded or floating emergents, predominantly sedges interspersed with other vegetation and shrubs; also open water zones vegetated with abundant submerged or floating aquatic plants (Hohman and Eberhardt 1998). In the Bozeman area, habitat is restricted to lakes and ponds.	Omnivore	Moist-soil and aquatic plant seeds and tubers; aquatic invertebrates	Migratory	NA	730 g	NA	G5	S5B	1992	2006	9
Rock Wren (<i>Salpinctes obsoletus</i>)	Ground	NA	Rock also found in nonrocky habitats, as long as there exists areas "rich in crevices, interstices, passageways, recesses, and nooks and crannies of diverse shapes and sizes"	Invertivore	Insects and other arthropods	Migratory	NA	17 g	NA	G5	S5B	1991	2004	11

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Ruby-crowned Kinglet (<i>Regulus calendula</i>)	Arboreal	Arboreal	In the west, nests in spruce-fir, lodgepole pine and Douglas-fir forests. Spring and fall migration includes a broad range of habitats: coniferous and deciduous forests, floodplain forests, willow shrubs, abandoned homesteads, rangeland, old fields, and suburban yards. Nest globular or elongated, usually pensile but may be placed on limb. In all cases nests protected from above by overhanging foliage.	Invertivore	Winter: spiders and their eggs, a variety of insects and their eggs, pseudoscorpions, small amounts of fruit, seeds and other vegetable matter. Breeding season: same as winter except no vegetable matter eaten	Migratory	NA	7 g	NA	G5	S5B	1992	2006	500
Ruddy Duck (<i>Oxyura jamaicensis</i>)	Riparian	Riparian	Breeding is usually on overgrown, shallow marshes with abundant emergent vegetation and some open water. Non-breeding birds are found on large, generally deeper waters with silty/muddy bottoms	Invertivore	primarily aquatic insects, crustaceans, zooplankton, and other invertebrates. Typically consumes small amount of aquatic vegetation and seeds. Forage almost exclusively by diving but occasionally forage by "skimming" water surface, straining food from water	Migratory	NA	590 g	NA	G5	S5B	1992	1993	4
Ruffed Grouse (<i>Bonasa umbellus</i>)	Ground	Arboreal/Shrub	found in dense, brushy, mixed-conifer and deciduous tree cover, often along stream bottoms. In the Bozeman area they are mostly in deciduous thickets in the foothills and mountains; also in riparian areas to the lowest elevation says they inhabit the denser cover of mixed conifer and deciduous trees and brush and are often along stream bottoms.	Omnivore	In winter deciduous tree buds and shrubs. In summer, a mixed diet of insects, green plants and berries, with young birds eating primarily insect	Migratory	NA	NA	NA	G5	S5	1977	2006	148
Rufous Hummingbird (<i>Selasphorus rufus</i>)	Riparian	Riparian	primarily aquatic insects, crustaceans, zooplankton, and other invertebrates. Typically consumes small amount of aquatic vegetation and seeds. Forage almost exclusively by diving but occasionally forage by "skimming" water surface, straining food from water	Invertivore	primarily aquatic insects, crustaceans, zooplankton, and other invertebrates. Typically consumes small amount of aquatic vegetation and seeds. Forage almost exclusively by diving but occasionally forage by "skimming" water surface, straining food from water	Migratory	NA	3 g	NA	G5	S5B	1991	2007	49
Savannah Sparrow (<i>Passerculus sandwichensis</i>)	Ground	Arboreal	widespread and abundant in open habitats throughout North America. During the breeding season its persistent buzzy song can be heard in agricultural fields, meadows, marshes, coastal grasslands, and tundra. During spring and fall migration it can be found in open fields, roadsides, dune vegetation, coastal marshes, edges of sewage ponds and other ponds in open country.	Omnivore	The main foods taken in winter include small seeds, fruits, and insects when available. During breeding season they eat adult insects, larval insects, insect eggs, small spiders, millipedes, isopods, amphipods, decapods, mites, small mollusks, seeds, and fruits.	Migratory	NA	25 g	Territories are small, ranging from 0.05 to 1.25 hectares	G5	S5B	1992	2004	12
Say's Phoebe (<i>Sayornis sayi</i>)	Aerial	NA	Open country, prairie ranches, sagebrush plains, badlands, dry barren foothills, canyons, and borders of deserts	Invertivore	Primarily flying or terrestrial insects, most frequently wild bees and wasps but also flies, beetles, and grasshoppers. Little vegetable matter	Migratory	NA	21 g	NA	G5	S5B			2
Sharp-shinned Hawk (<i>Accipiter striatus</i>)	Carnivore	NA	commonly use heavy timber, especially even-aged stands of conifers, but sometimes hunt in open areas	Carnivores	almost entirely on songbirds, although they occasionally take small mammals and insects	Non-Migratory	NA	174 g	NA	G5	S4B	1991	2003	17
Solitary Vireo (<i>Vireo solitarius</i>)	Arboreal	NA	Mixed coniferous-deciduous woodland, humid montane forest; in migration and winter also in "a variety of wooded habitats, but favors tall woodland with live oaks and pines in the temperate zone.	Invertivore	Eats mostly insects, some spiders and small fruits; forages among foliage and branches of trees and shrubs. Eats fruits and insects in about equal proportions	Migratory	NA	17 g	NA	G5	SNR	1993	1994	9
Song Sparrow (<i>Melospiza melodia</i>)	Arboreal	NA	Wide range of forest, shrub, and riparian habitats, but limited to those adjacent to fresh water more often in arid environments	Omnivore	In nonbreeding period, primarily seeds, fruits, and invertebrates, as available. During breeding, primarily insects and other small invertebrates; some seeds and fruit	Migratory	NA	21 g	NA	G5	S5B	1991	2006	80
Sora (<i>Porzana carolina</i>)	Riparian	Riparian	Primarily shallow freshwater emergent wetlands (e.g., marshes of cattail, sedge, blue-joint, or bulrush), less frequently in bogs, fens, wet meadows, and flooded fields, sometimes foraging on open mudflats adjacent to marshy habitat.	Omnivore	Eats mollusks, insects, seeds of marsh plants, duckweed	Migratory	NA	NA	NA	G5	S5B	1991	2000	9
Spotted Sandpiper (<i>Actitis macularius</i>)	Riparian	Riparian	Shores of lakes, ponds, and streams, sometimes in marshes; prefers shores with rocks, wood, or debris; also mangrove edges in Caribbean. Nests near freshwater in both open and wooded areas, less frequently in open grassy areas away from water; on ground in growing herbage or low shrubby growth, or against log or plant tuft	Aquatic Invertivore	Eats mainly small invertebrates obtained from surface or by probing along shores or some distance inland if insects are abundant there	Migratory	NA	40 g	NA	G5	S5B	1992	2006	29

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Spotted Towhee (<i>Pipilo maculatus</i>)	Ground	NA	Uses a wide variety of shrubby habitats characterized by deep litter and humus on ground, and sheltering vegetation overhead. Undergrowth of open woodland, forest edge, second growth, brushy areas, chaparral, riparian thickets, woodland	Invertivore	Forages on the ground beneath shrubs and undergrowth, using a two-footed scratching maneuver to find food among loose debris. Eats various invertebrates, seeds, small fruits, some small vertebrates	Migratory	NA	42 g	NA	G5	S5B	1991	2006	78
Spruce Grouse (<i>Falcipennis canadensis</i>)	Ground	NA	dense forest types such as alpine fir, Engelmann spruce, or lodgepole pine. Winter home ranges northeast of Missoula are covered by Douglas fir, ponderosa pine, lodgepole pine and larch. Douglas fir provided the most important cover; the average size being 24.1 hectares	Herbivore	Conifer needles (larch, ponderosa pine, lodgepole pine) were the main food in late fall through early spring. In summer, herbaceous vegetation and insects were utilized.	Migratory	NA	492 g	NA	G5	S4	1992	2004	16
Steller's Jay (<i>Cyanocitta stelleri</i>)	Ground	Arboreal	Coniferous and mixed coniferous-deciduous forest, open woodland, orchards and gardens including humid coniferous forest in nw. North America. Habituates readily to humans and is well known at feeders, picnic areas, and campgrounds. Nests typically placed on horizontal branches close to trunk, often close to top of tree. When nesting close to human habitation, frequently nests close to a window, building, or path, above ground in bushes or trees.	Omnivore	Consumes wide variety of animal and plant food including arthropods, nuts, seeds, berries, fruits, small vertebrates, and eggs and young of smaller birds. At feeders, picnic areas and campgrounds, consumes wide variety of foods such as suet, sunflower seeds, peanuts, meat, cheese, bread, and cookies	Non Migratory	NA	106 g	NA	G5	S5	1987	2005	83
Swainson's Thrush (<i>Catharus ustulatus</i>)	Arboreal	Arboreal	Coniferous and mixed coniferous-deciduous forest, open woodland, orchards and gardens including humid coniferous forest in nw. North America. Habituates readily to humans and is well known at feeders, picnic areas, and campgrounds. Nests usually in small tree, close to trunk, often 2 m or less above ground; often in conifer, sometimes deciduous tree or shrub.	Omnivore	Berries and insects. Breeding and spring migrating populations tend to be insectivorous; fall migrating and wintering populations more frugivorous	Non Migratory/ Altitudinal	NA	23-45 g	Territory sizes of 1.7 to 3.3 acres	G5	S5B	1991	2005	1387
Tennessee Warbler (<i>Vermivora peregrina</i>)	Arboreal	Arboreal	Openings of northern woodland, edges of dense spruce forests, cleared balsam tamarack bogs, grassy places of open aspen and pines, alder and willow thickets, open deciduous second growth. In migration and winter generally in single species flocks in tops of trees of various woodland types--not typically in continuous mature forest; in winter prefers semi-open, second growth, coffee plantations, gardens. Nests in hollow of moss in bog, or on higher level ground or hillside, in thickets or in open at base of grass or shrub	Invertivore	Eats insects and spiders, seeds, fruit juices; forages over terminal twigs and leaves of trees and in dense patches of weeds	Migratory	NA	10 g	NA	G5	S2S4 B	1991	2000	10
Townsend's Solitaire (<i>Myadestes townsendi</i>)	Ground	Ground	Open woodland, pinyon-juniper association, chaparral, desert and riparian woodland nest sites were in cutbanks and 2 were in open woodlands	Invertivore	In Missoula, insects were the primary summer food, obtained primarily by ground predation. Rocky Mountain juniper cones were the primary food during late winter. Feeds on insects (e.g., caterpillars, beetles, wasps, ants, bugs) and fruit (e.g., juniper berries, and berries of rose, cedar mistletoe, madrona), also pine seeds. Flies out from a perch and catches insects in the air.	Migratory	NA	34 g	NA	G5	S5	1991	2004	515
Townsend's Warbler (<i>Dendroica townsendi</i>)	Arboreal	Arboreal	Tall coniferous and mixed coniferous-deciduous forest at various elevations, from wet coastal forest at sea level to dry subalpine forest. Most abundant in unlogged, old-growth forest, but also common in late successional stages. Uncommon in logged forest. Appears to prefer conifers; may nest 2.7-4.5 m above ground, maybe higher	Invertivore	Insects. Honeydew excreted by scale insects in low-latitude cloud forests. Winter: gleans small insects and caterpillars in foliage at all heights, occasionally hovers and plucks them from undersides of leaves; hawks flying insects	Non Migratory	NA	9 g	NA	G5	S5B	1991	2005	1306
Tree Swallow (<i>Tachycineta bicolor</i>)	Aerial	Arboreal	Open fields, meadows, marshes, beaver ponds, lakeshores and other wetland margins. Uses trees only for nesting and occasional roosting.	Invertivore	Mostly flying insects, though vegetable matter is eaten during unfavorable weather conditions. Forage over open water, marshes, ponds, and fields, as well as in shrubby habitat.	Migratory	NA	20 g	NA	G5	S5B	1992	2006	27
Turkey Vulture (<i>Cathartes aura</i>)	Carnivore	Cliffs	Turkey vultures forage in a variety of habitats, including grasslands, badlands, open woodlands, and farmlands. Nesting in the northern Rockies is usually done on cliff ledges under overhangs, or in rock crevices, often in river valleys	Carnivore	Carion is the primary food, but they sometimes prey on small mammals.	Migratory	NA	1467 g	NA	G5	S4B	1992	2006	18

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Varied Thrush (<i>Ixoreus naevius</i>)	Ground	Arboreal	Humid coastal and interior montane coniferous forest, deciduous forest with dense understorey, and tall shrubs (especially alder); in migration and winter also open woodland and chaparral. Usually nests in a small conifer, sometimes a deciduous tree, 3-4.5 m above ground	Omnivore	Feeds in trees or forages on the ground for insects, earthworms, seeds, and berries.	Non Migratory	NA	78 g	NA	G5	S5B	1990	2005	619
Vaux's Swift (<i>Chaetura vauxi</i>)	Aerial	Arboreal	During breeding prefer late stages of coniferous forests and deciduous forests mixed with coniferous. More common in old-growth forests than in younger stands. During spring and fall migrations prefer forests and open areas; roost trees and chimneys important as they allow swifts to avoid exposure and conserve body heat. Hollow trees are its favored nesting and roosting sites. Nest in hollow trees in the forest; less commonly in chimneys.	Invertivore	Almost entirely insects and spiders. Catches its prey from the air.	Non Migratory	NA	17 g	NA	G5	S4B	1991	2002	12
Veery (<i>Catharus fuscescens</i>)	Ground	Riparian	Generally inhabits damp, deciduous forests. Has a strong preference for riparian habitats in several regions, including the Great Plains. Prefers disturbed forest, probably because denser understorey is not found in undisturbed forests. Breeds in early-successional, damp, deciduous forests, often nesting near streamside thickets or swamps. Nest are typically on or near the ground, most often elevated in or at the base of a bush or small tree.	Omnivore	Primarily a ground forager, with a diet fairly evenly divided between insects and fruit. Roughly 60% insects, 40% fruit, feeding primarily on insects as breeders and on fruit late summer and fall.	Migratory	NA	31 g	NA	G5	S4B	1994	1995	7
Vesper Sparrow (<i>Poocetes gramineus</i>)	Ground	Ground	In central Montana they nest on the ground under big sagebrush, but concealment of the nest is not greatly important. They are found in areas where vegetation was short and dense, with a high percentage of cover	Omnivore	In central Montana, 70-90% of food was animal (mostly Coleopterans), while 3 to 23% was plant (mostly grass seeds)	Migratory	NA	27 g	NA	G5	S5B	1991	2006	73
Violet-green Swallow (<i>Tachycineta thalassina</i>)	Aerial	Arboreal	Occurs principally in montane coniferous forests. Breeding range includes open deciduous, coniferous, and mixed woodlands. Often perches on wires and exposed tree branches.	Invertivore	Flying insects exclusively. Not known to feed on seeds or berries.	Migratory	NA	14 g	NA	G5	S5B	1991	2006	27
Warbling Vireo (<i>Vireo gilvus</i>)	Ground	Arboreal	Throughout range, shows a strong association with mature mixed deciduous woodlands especially along streams, ponds, marshes, and lakes but sometime in upland areas away from water. Also found in young deciduous stands that emerge after a clear-cut. In general, overall habitat structure consists of large trees with semi-open canopy. Other habitats include urban parks and gardens, orchards, farm fencerows, campgrounds, deciduous patches in pine forests, mixed hardwood forests, and rarely, pure coniferous forests. Usually nests at end of branch in a deciduous tree, 9-18 m above ground, or 1-3.5 m above ground, in shrub or orchard tree	Invertivore	Insects, throughout the year. Some fruit in winter	Migratory	NA	12 g	Territory sizes of 3.4 to 5.6 acres	G5	S5B	1992	2006	435
Western Bluebird (<i>Sialia mexicana</i>)	Ground		Can usually be found in open coniferous and deciduous woodlands, parklike forests, edge habitats, burned areas and where moderate amounts of logging have occurred, provided a sufficient number of larger trees and snags remain to provide nest sites and perches. Nests usually found in rotted or previously excavated cavities in trees and snags, or between trunk and bark.	Invertivore	Insects during the warmer months, but forages primarily on berries and fruits through the winter. Forages by flycatching and by dropping from perch to ground.	Non Migratory	NA	29 g	averaged 0.43 hectares and 0.56 hectares	G5	S4B	1991	2003	11
Western Grebe (<i>Aechmophorus occidentalis</i>)	Riparian-Opportunist		Lives on fresh water lakes and marshes which have large areas of open water and vegetation around it.	Piscivore, Invertivore	Feeds mainly on fish, but will also eat salamanders, crustaceans, polychaete worms, and insects. They tend to be opportunists	Migratory	NA	1477 g	20 hectares or more open water	G5	S4B	1987	1991	4
Western Kingbird (<i>Tyrannus verticalis</i>)	Aerial/Ground	Arboreal/Shrub	Open and partly open country, especially savanna, agricultural lands, and areas with scattered trees, also desert.	Invertivore	Primarily insectivorous; feeds on wasps, beetles, moths, caterpillars, grasshoppers, true bugs. Also eats spiders, millipedes, and some fruit. May occasionally take tree frogs	Migratory	NA	40 g	Foraging range at least 400 meters from nest	G5	S5B	1991	2006	8
Western Meadowlark (<i>Sturnella neglecta</i>)	Ground	Ground	Most common in native grasslands and pastures, but also in hay and alfalfa fields, weedy borders of croplands, roadsides, orchards, or other open areas; occasionally desert grassland. Preference shown for habitats with good grass and litter cover.	Grainivore, Invertivore	Grain and weed seeds, and insects. Favorite insect foods include beetles, weevils, wireworms, cutworms, grasshoppers, and crickets. Seasonal differences: grain during winter and early spring, insects late spring and summer, weed seeds in fall.	Migratory	NA	106 g	4-13 hectares	G5	S5B	1992	2006	45

Attachment A-2. Bird Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Global Rank	State Rank	Observations in Lincoln, Co.,		
	Foraging	Nesting										Oldest	Most Recent	Number
Western Tanager (<i>Piranga ludoviciana</i>)	NA	Arboreal	Favors open woodlands, but occasionally extends into fairly dense forests. During migration, frequents a wide variety of forest, woodland, scrub and partly open habitats and various human-made environments such as orchards, stands of trees in suburban areas, parks, and gardens.	Frugivore, Invertivore	Feeds predominantly on insects during the breeding season, but it also incorporates fruits and berries in its diet whenever it can	Migratory	NA	28 g	NA	G5	S5B	1991	2006	1158
Western Wood-pewee (<i>Contopus sordidulus</i>)	Aerial	Arboreal	Seen wherever there are clearings or groves of deciduous trees along the river valleys	Invertivore	Flying insects, especially flies, ants, bees, wasps, and beetles, moths and bugs.	Migratory	NA	13 g	NA	G5	S5B	1992	2006	34
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	Arboreal	Arboreal	A common resident of deciduous forests in North America. Also in mixed deciduous and coniferous forests. Favors woodland edges over more central locations, preferring open areas. Over much of its range the presence of some oaks seems to be a requirement.	Granivore, Invertivore	Feeds on a variety of insects and plant matter (acorns, nuts, etc).	Migratory	NA	21 g	10-20 hectares feeding territory	G5	S4	1992	2006	58
White-crowned Sparrow (<i>Zonotrichia leucophrys</i>)	Ground	Ground/Shrub/Arboreal	Necessary habitat features of breeding territories include grass, either pure or mixed with other plants; bare ground for foraging; dense shrubs or small conifers thick enough to provide a roost and conceal a nest; standing or running water on or near territory; and tall coniferous trees, generally on periphery of territory.	Granivore, Invertivore	Main foods taken in winter include seeds, buds, grass, fruits, and arthropods, when available. During breeding season arthropods (principally insects) and seeds are taken.	Migratory	NA	29 g	NA	G5	S5B	1989	2003	41
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	Ground	Ground	Coniferous and mixed forest, forest edge, clearings, bogs, brush, thickets, open woodland. In migration and winter also in deciduous forest and woodland, scrub, shrubbery, gardens, parks, cattail marshes.	Frugivore, Granivore, Invertivore	Eats mostly weeds seeds, also small fruits, buds, and insects.	Migratory	NA	26 g	NA	G5	SNA	1994	1994	3
White-winged Crossbill (<i>Loxia leucoptera</i>)	NA	Arboreal	Coniferous forest (especially spruce, fir or larch), mixed coniferous-deciduous woodland, and forest edge; in migration and winter also may occur in deciduous forest and woodland	Granivore, Invertivore	Eats seeds (e.g., of conifers, birches, grasses, junipers, etc.) and insects; mainly conifer seeds, which also comprise diet of nestlings	Non-Migratory	NA	28 g	NA	G5	S4	1991	2000	28
Wild Turkey (Meleagris gallopavo)	Ground	Ground	Open ponderosa pine forest in rugged terrain, interspersed with grassland and brushy draws is the preferred habitat (FWP). Open ponderosa pine-grassland cover types are most widely used in the Longpine Hills during summer and early fall; canyon bottoms at lower elevations, grain fields and livestock feeding areas are utilized in late fall and winter.	Frugivore, Granivore, Herbivore, Invertivore	Summer foods include insects (primarily grasshoppers), bearberry, snowberry and skunkbrush sumac fruits, grass leaves and stems, and Carex seeds; winter foods are grains, hawthorn and snowberry fruits, and grass leaves, stems and heads.	Non-Migratory	NA	7400 g	260 to 520 hectares	G5	SNA	1994	2005	12
Williamson's Sapsucker (<i>Sphyrapicus thyroideus</i>)	Arboreal	Arboreal	Coniferous forest, especially fir and Lodgepole Pine; in migration and winter also in lowland forest.	Invertivore	Drills holes in trees and consumes sap, cambium and insects. Ants may comprise 86% of its animal food; also eats wood-boring larvae, moths of spruce budworms, etc.	Migratory	NA	48 g	Reported territory sizes vary from 4 hectares to 6-7 hectares	G5	S3S4B	1991	2002	39
Willow Flycatcher (<i>Empidonax traillii</i>)	Aerial	Riparian	Strongly tied to brushy areas of willow (<i>SALIX</i> spp.) and similar shrubs. Found in thickets, open second growth with brush, swamps, wetlands, streambanks, and open woodland. Common in mountain meadows and along streams; also in brushy upland pastures (especially hawthorn) and orchards. The presence of water (running water, pools, or saturated soils) and willow, alder (<i>ALNUS</i> spp), or other deciduous riparian shrubs are essential habitat elements	Invertivore	Eats mainly insects and occasionally berries, 96 percent of diet is animal matter, most of which is flying insects.	Migratory	NA	14 g	0.1 to 0.9 hectares	G5	S5B	1991	2006	26
Wilson's Phalarope (<i>Phalaropus tricolor</i>)	Riparian	Riparian - ground	During spring, the species is widespread in the valley in lakes, ponds and flooded fields. Summer birds are restricted to marshy borders of lakes and ponds	Invertivore	Small aquatic invertebrates in freshwater or hypersaline environments; also some terrestrial invertebrates.	Migratory	NA	68 g	Usually nests less than 100 meters from shoreline	G5	S4B	1995	1995	2
Wilson's Snipe (<i>Gallinago delicata</i>)	Ground	Ground	During summer birds are widely distributed in the valley in moist meadows. In winter, they occur along warm, bog-bordered streams in the valley. Requires soft organic soil rich in food organisms just below surface, with clumps of vegetation offering both cover and good view of approaching predators. Avoids marshes with tall, dense vegetation (cattails, reeds, etc.).	Invertivore	Eats mostly larval insects, but also takes crustaceans, earthworms, and mollusks. Stomachs contain as much as 66% plant material, but probably little or no energy is obtained from plants	Migratory	NA	128 g	Common Snipes breed throughout the state. Most wintering records are for western Montana.	G5	S5	1991	2006	54
Wilson's Warbler (<i>Wilsonia pusilla</i>)	Arboreal/Aerial	Ground	Breeding territories are usually located in riparian habitat or wet meadows with extensive deciduous shrub thickets. Likes edges of beaver ponds, lakes, bogs and overgrown clear-cuts of montane and boreal zones.	Invertivore	Bees, flies, mayflies, spiders, beetles and caterpillars. Occasionally eats berries.	Migratory	NA	7 g	Ranges from about 0.2 to 2.0 hectares.	G5	S5B	1991	2005	349

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration	Longevity	Size	Home Range	Observations in Lincoln, Co.,				
	Foraging	Nesting								Global Rank	State Rank	Oldest	Most Recent	Number
Winter Wren (<i>Troglodytes troglodytes</i>)	Ground/Shrub	Arboreal - Cavity	Coniferous forest, primarily with dense understory and near water, and in open areas with low cover along rocky coasts, cliffs, islands, or high mtn. areas, logged areas with large amounts of slash; in winter and migration also in deciduous woods with understory, thickets, brushy fields.	Invertivore	Eats almost entirely insects (beetles, Diptera, caterpillars) and spiders.	Migratory	NA	9 g	NA	G5	S4	1991	2005	487
Wood Duck (<i>Aix sponsa</i>)	Riparian/Ground	Arboreal - Cavity	Wide variety of habitats: creeks, rivers, overflow, bottomlands, swamps, marshes, beaver and farm ponds.	Omnivore	Omnivore with a broad diet. Seeds, fruits and aquatic and terrestrial invertebrates are main foods taken.	Migratory	NA	681 g	Home ranges of of fledged broods range up to 12.8 kilometers.	G5	SSB	1996	2006	6
Yellow Warbler (<i>Dendroica petechia</i>)	Arboreal/Aerial	Arboreal/Shrub	Found throughout much of North America in habitats categorized as wet, deciduous thickets. Found especially in those dominated by willows.	Invertivore	Main foods include insects and other arthropods. May take wild fruits occasionally.	Migratory	NA	10 g	Breeding territories are as small as 0.16 hectares.	G5	SSB	1991	2006	51
Yellow-breasted Chat (<i>Icteria virens</i>)	Arboreal	Arboreal/Shrub	Found in low, dense vegetation without a closed tree canopy, including shrubby habitat along stream, swamp, and pond margins; forest edges, regenerating burned-over forest, and logged areas; and fencerows and upland thickets of recently abandoned farmland	Frugivore, Invertivore	Adults feed on small invertebrates (mainly insects and spiders), fruit and berries when available.	Migratory	NA	26 g	Territory size averages 1.24 hectares.	G5	SSB	1991	1993	4
Yellow-headed Blackbird (<i>Xanthocephalus xanthocephalus</i>)	Ground	Riparian	Primarily prairie wetlands, but also common in wetlands associated with quaking aspen parklands, mountain meadows, and arid regions. Scattered colonies occur on forest edges and on larger lakes in mixed-wood boreal forest.	Granivore, Invertivore	During breeding season specializes in "aquatic" prey; feeds aquatic insects to nestlings. Consumes primarily cultivated grains and weed seeds during the postbreeding season.	Migratory	NA	80 g	Forages up to 1.6 kilometers from nesting area.	G5	SSB	1993	2006	6
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	Arboreal/Aerial/Ground	Arboreal	Nests in forests or open woodlands. In migration and winter found in open forests, woodlands, savanna, roadsides, pastures, and scrub habitat.	Invertivore	Feeds on insects (ants, wasps, flies, beetles, mosquitoes, etc.), spiders, some berries and seeds.	Migratory	NA	13 g	NA	G5	SSB	1991	2005	1716

Attachment A-3. Mammalian Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
Beaver (<i>Castor canadensis</i>)	Riparian	Riparian	Ponds, small lakes, meandering streams, and rivers. Requires water and associated woody vegetation.	Herbivore	variety of woody and herbaceous species. Willows, mountain alder, and aspen	Non-migratory	11 years in wild	Adults 16-23 kg (35-50 pounds), Kits 0.5 kg or less (1 pound) at birth, when they are about 38 cm (15 inches) long	NA	G5	S5	1947	2006	4
Black Bear (<i>Ursus americanus</i>)	Ground/Shrub/Arboreal	Ground	Dense forests; riparian areas; open slopes or avalanche chutes during spring green-up (FWP). Habitat use tied to seasonal food avail./plant phenology. Dry mtn meadows in early spring, snow slides, stream bottoms, wet meadows early & mid-summer. May concentrate in berry & whitebark pine areas in fall. Sympatric with grizzly bear but more prone to occupying closed canopy areas. Natural cub and adult mortality low, sub-adult mortality higher. Dens beneath downed trees, hollow trees, roots or other shelter.	Omnivore	Grasses, sedges, berries, fruits, inner bark of trees, insects, honey, eggs, carrion, rodents, occasional ungulates (especially young and domestic), and (where available) garbage. Varies. Spring--primarily vegetation (grasses, umbels, & horsetails). Summer--herbaceous & fruits. Fall--berries & nuts, some vegetation. Insects a frequent component of diet. Also mammals, birds, & carrion	Non-migratory/Semi-hibernates in winter	NA	90 - 240+ kg	NA	G5	S5	1917	2006	20
Bobcat (<i>Lynx rufus</i>)	Carnivore	NA	Utilizes wide variety of habitats; known to be an animal of "patchy" country. Prefers rimrock and grassland/shrubland areas. Often found in areas with dense understory vegetation and high prey densities. Natural rocky areas are preferred den sites May be active during all hours but is primarily nocturnal. Solitary animal that is difficult to observe in the wild. In Central MT selected for cover types (52+% canopy cover) correlated with high prey densities. In W. MT den sites within caves, btwn boulders, in hollow logs, or abandon mine shafts.	Carnivore	Snowshoe hares and jackrabbits are the most common prey. Also feeds heavily on medium-sized rodents. Will eat carrion.	Non-migratory/NA	NA	6.7 - 15.7 kg	In L.A. about 5 sq km for males and 1 sq km for females. In Idaho, home ranges averaged 42 sq km for males and 19 sq km for females	G5	S5	1997	1997	365
Bushy-tailed Woodrat (<i>Neotoma cinerea</i>)	Ground	Dens - rock crevices, logs	Occurs in crevices where there are large amounts of sticks, leaves & other debris used to build nest. Rockslides, rocky slopes, abandoned homesites, badlands. Occas. lodges nest in tree forks high above ground	Herbivore	Not selective in its diet of foliage, fruits and seeds of shrubs & forbs, conifer & fungi.	Non-migratory/NA	NA	NA	NA	G5	S5	1975	2006	4
Columbian Ground Squirrel (<i>Spermophilus columbianus</i>)	Ground	NA	Intermontane valleys, open woodland, subalpine meadows, even alpine tundra. Subalpine basins, clearcuts, and other disturbed areas. At high elevations, may use rockslides/forage in meadows. Prefers g-lands & sedges.	Herbivore	Grasses, leafy vegetation, and bulbs. May increase use of fruits and seeds as season progresses. Uses a small amount of animal matter: insects, fish, carrion.	Non-migratory/Dormancy	NA	340 - 812 g	NA	G5	S5	1922	2006	12

Attachment A-3. Mammalian Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Observation in Lincoln, Co.,				
	Foraging	Breeding, Resting								Global Rank	State Rank	Oldest	Most Recent	Number
Coyote (<i>Canis latrans</i>)	Scavenger	NA	Utilizes almost any habitat, including urban areas, where prey is readily available. Prefers prairies, open woodlands, brushy or boulder-strewn areas. Coyote abundance is tied to food availability. Mainly nocturnal, true scavenger, territorial. Occupies diverse habitats.	Omnivore	Will eat almost anything, plant or animal. Emphasizes small mammals, fawns, plants, birds, and invertebrates. During winter, often preys on deer. Commonly preys on domestic sheep. Rodents & rabbits imp. year round. Grasshoppers, crickets, fruits may be used in summer & fall. Food habits vary between seasons & areas. May take adult deer in winter. Young deer, elk, & pronghorn in spring.	Non-migratory / NA	NA	9 - 22 kg	NA	G5	S5	1999	2006	3
Deer Mouse (<i>Peromyscus maniculatus</i>)	Ground	Ground-Burrows	In virtually all habitats - sagebrush desert, grasslands, riparian areas, montane, subalpine coniferous forests & alpine tundra. Usually not seen in wetlands. In forest areas densities peak about 2-5 years after clear-cutting, then decline as succession advances. 15 yrs. after cut, uncut & cut densities similar. On prairie production may be linked to precipitation. Nests in burrow in ground in trees, stumps and buildings	Omnivore	Omnivorous diet although dentition is adapted for seed eating. Invertebrates important in warm months, green plant material a minor but important component. Stores some food in burrow	Non-migratory/No hibernation	Rarely lives more than 2 years in wild and from 5-8 years in captivity	18 - 35 g	NA	G5	S5	1895	2006	60
Dusky or Montane Shrew (<i>Sorex monticolus</i>)	Ground	Ground - Beneath stumps, logs, trees	High altitude spruce-fir forest, alpine tundra. Non-breeders territorial. Breeders apparently not territorial. First-year animals may not be reproductively active. Nests in stumps, logs, beneath trees.	Invertivore	Similar to other long-tailed shrews: eats mostly invertebrates	Non-migratory/NA	NA	NA	NA	G5	S5	2006	2006	7
Elk (<i>Cervus canadensis</i>)	Ground/Grazer	NA	Mainly coniferous forests interspersed with natural or man-made openings (mountain meadows, grasslands, burns, and logged areas) (FWP). Varies between populations & areas. Basic habitat components: security, shelter (may use to maintain thermal equilibrium) & forage production. Moist sites preferred in summer.	Herbivore	Grasses, sedges, forbs, deciduous shrubs (especially willow and serviceberry) and young trees (especially chokecherry and maple), some conifers (FWP). Varies between ranges.	Migratory in some areas (Sun River, North Yellowstone) moving between seasonal ranges, non-migratory in others.	14 years in the wild (25 years in captivity)	Males (315 - 450 kg); Females (225 - 270 kg)	NA	G5	S5	1977	2006	5
Fisher (<i>Martes pennanti</i>)	Carnivore	Ground/Arboreal	Although they are primarily terrestrial, fishers are well adapted for climbing. When inactive, they occupy dens in tree hollows, under logs, or in ground or rocky crevices, or they rest in branches of conifers (in the warmer months). Fishers occur primarily in dense coniferous or mixed forests, including early successional forests with dense overhead cover. Dens in hollow tree or on ground	Carnivore	Mammals (small rodents, shrews, squirrels, hares, muskrat, beaver, porcupine, raccoon, deer caribou); also birds and fruit. Snowshoe hares are an important dietary item for fishers in Montana, as is deer caribou. Known for their skill at killing porcupines	Fishers are non-migratory, but may make extensive movements up to a maximum of 40 kilometers in 3 days / NA	More than 9 years in captivity	Males (2.7 - 5.4 kg); Females (1.4 - 3.2 kg)		G5	S3	1965	1992	18

Attachment A-3. Mammalian Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Observation in Lincoln, Co.,				
	Foraging	Breeding, Resting								Global Rank	State Rank	Oldest	Most Recent	Number
Golden-mantled Ground Squirrel (<i>Spermophilus lateralis</i>)	Ground	Ground-Burrows	Occurs throughout the montane and subalpine forests, where- ever the rocky habitat it dwells in (outcrops and talus slopes) is present. It will range above timberline and even (in summer at least) into alpine tundra. Short, simple, concealed burrows--entrance near rock, stump, log, or bush	Omnivore	Seeds, fruits, insects, eggs, meat (Burt and Grossenheider, 1952)	Non-migratory/ Hibernates	NA	170 - 276 g	NA	G5	S4	1966	1966	2
Gray Wolf (<i>Canis lupus</i>)	Carnivore	NA	No particular habitat preference except for the presence of native ungulates within its territory on a year round basis. Wolves establishing new packs in Montana have demonstrated greater tolerance of human presence and disturbance than previously thought characteristic of this species. They have established territories where prey are more abundant at lower elevations than expected, especially in winter.	Carnivore	Opportunistic carnivores that predominantly prey on large ungulates. Main prey in Montana include deer, elk, and moose. Also alternative prey, such as rodents, vegetation and carrion. Hunt in packs, but lone wolves and pairs are able to kill prey as large as adult moose.	Not migratory but may move seasonally following migrating ungulates within its territory.	NA	31.5 - 54 kg	NA	G4	S3	1974	2000	47
Grizzly Bear (<i>Ursus arctos horribilis</i>)	Ground/Shrub	NA	In Montana, grizzlies primarily use meadows, seeps, riparian zones, mixed shrub fields, closed timber, open timber, sidehill parks, snow chutes, and alpine slabrock habitats. Habitat use is highly variable between areas, seasons, local populations, and individuals	Omnivore	large vegetative component (more than half) to their diet and have evolved longer claws for digging and larger molar surface area to better exploit vegetative food sources	No true migration occurs, although grizzly bears often exhibit discrete elevational movements from spring to fall, following seasonal food availability/ Hibernates	25 years or more in captivity	146 - 282 kg	NA	G4	S2S3	1912	2003	14
Heather Vole (<i>Phenacomys intermedius</i>)	Ground	Ground-Burrows	Most common in subalpine spruce-fir forest w/ evergreen shrub ground cover, also in timberline krummholz, alpine tundra. Sometimes in montane yellowpine-doug fir forests w/ bearberry-twinflower understory. Winter nest is a hollow sphere of twigs & lichens about 6 inches diam., above ground in protected spot. Summer nest 4-10 in. underground (Banfield 1974). Does not tend to construct runways.	Herbivore	Twigs, berries	Non-migratory/NA	NA	NA	NA	G5	S4	1948	2006	15
Hoary Marmot (<i>Marmota caligata</i>)	Ground	NA	Talus slopes, alpine meadows, high in mountains near timberline	Herbivore	herbs, grasses, sedges	Hibernates	NA	3.6 - 9 kg	NA	G5	S3S4	1949	2006	12
Long-tailed Vole (<i>Microtus longicaudus</i>)	Ground	Ground-Burrows	Riparian valley bottoms to alpine tundra, sagebrush-grassland semi-desert to subalpine coniferous forests. In forested areas may not make runways. Subordinate to other species of voles. Streambanks and occasionally in dry situations. Nests above ground in winter and in burrows in summer.	Herbivore	Grasses, bulbs, bark of small twigs.	NA/NA	NA	37 - 57 g	NA	G5	S4	1895	1993	13

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
Long-tailed Weasel (<i>Mustela frenata</i>)	Carnivore	Ground- Burrows	Found in almost all land habitats near water. Has the broadest ecological and geographical range of the North American weasels. Prefers areas with abundant prey. Avoids dense forest, most abundant in late seral ecotones. Primarily nocturnal, but sometimes active during the day. Quite fearless and curious. Mainly terrestrial but can climb and swim well. Nests in old burrows of other animals. Occupies a diverse range of habitats. More prone to open country and forest openings than <i>M. erminea</i> . Common in intermontane valleys and open forests where <i>M. erminea</i> is absent. May occur up to alpine tundra	Carnivore	More of a generalist than the short-tailed and least weasels. Feeds mostly on small mammals up to rabbit-sized, but eats birds and other animals as well	Non-migratory/No hibernation	NA	Males (198 - 340 g); Females (85 - 198 g)	NA	G5	S5	1940	1992	3
Lynx (<i>Lynx canadensis</i>)	Carnivore	NA	Subalpine forests between 1,220 and 2,150 meters in stands composed of pure lodgepole pine but also mixed stands of subalpine fir, lodgepole pine, Douglas fir, grand fir, western larch and hardwoods. In extreme northwestern Montana, primary vegetation may include cedar-hemlock habitat types	Carnivore	The primary winter food for lynx throughout their range is the snowshoe hare, comprising 35 to 97% of their diet. Red squirrels are also an important prey item, particularly when snowshoe hare populations are reduced. Summer diets are not as well known but are probably more varied. Lynx in Montana probably prey on a wider variety of species throughout the year because of generally lower snowshoe hare densities and available alternate prey	Non-migratory, but movements of 90 to 125 miles have been recorded between Montana and Canada / NA	NA	6.7 - 13.5 kg	NA	G5	S3	1941	2005	215
Marten (<i>Martes americana</i>)	Carnivore	NA	Primarily a boreal animal preferring mature conifer or mixed wood forests. Severe forest disturbance can significantly reduce habitat value. Uses deadfall and snags as den sites. Spends much time in trees but will also forage on the ground.	Carnivore	Opportunistic feeder that primarily feeds on small mammals. Meadow voles and red-backed voles were staples in Glacier NP. Also used Cricetidae, jumping mice, shrews, ground squirrels, and snowshoe hares. Use of birds, insects, and fruit variable by season.	Non-migratory/NA	17 years in captivity	Males (754 - 1248 g); Females (681 - 851 g)	NA	G5	S4	1945	1966	78
Masked Shrew (<i>Sorex cinereus</i>)	Ground	Ground	Coniferous forest. In western Montana, where <i>S. vagrans</i> also occurs, <i>S. cinereus</i> is usually restricted to drier coniferous forest habitat. Moist situations in forests, open country, brushland. Nest of dry leaves or grasses, in stumps or under logs or piles of brush.	Invertivore	Invertebrates, salamanders, small mice. In winter, seeds may be main item in diet.	Non-migratory/NA	NA	3 - 6 g	NA	G5	S5	1966	2006	16
Meadow Vole (<i>Microtus pennsylvanicus</i>)	Ground	Ground- Burrows	Wet grassland habitat but not above timberline in grassy alpine tundra. Where <i>M. montanus</i> not present, <i>M. pennsylvanicus</i> may inhabit drier grasslands. Makes extensive runways. In E MT mean home range was 0.13 ac. for females, 0.14 ac. for lactating females, 0.23 ac. for males (McCann 1976). Low longevity, high juvenile mortality.	Herbivore	Grasses, sedges & herbaceous plants. May use fungi, particularly endogone. Will use insects. Occasionally will use carrion. Reported to feed on apple trees (bark and vascular tissues of lower trunk and roots)	Non-migratory/NA	1 to 3 years in wild	28 - 70 g	NA	G5	S5	1895	2006	57

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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
Mink (<i>Mustela vison</i>)	Riparian	Ground	Usually found along streams and lakes. Commonly occurs in marshes and beaver ponds. Permanence of water and dependable source of food are most important habitat components. Often uses den sites of other animals and is commonly found in association with muskrats. Semi-aquatic forager. Can kill prey larger than itself. Chiefly nocturnal, territorial, and secretive. Dens underneath piles of brush or driftwood, under rocks, in hollow logs, and in houses or dens abandoned by beavers or muskrats.	Piscivore	Preys primarily on small mammals, birds, eggs, frogs, and fish. Its diet is almost entirely animal. During summer preys on waterfowl. Order of importance varies.	Non-migratory. Males make extensive movements and juveniles disperse / NA	NA	Males (681 - 1362 g); Females (567 - 1089 g)	NA	G5	S5	1939	1943	2
Moose (<i>Alces alces</i>)	Ground/Grazer	NA	Variable: in summer, mountain meadows, river valleys, swampy areas, clearcuts; in winter, willow flats or mature coniferous forests; best ability of any Montana ungulate to negotiate deep snow	Herbivore	Browse, including large saplings; aquatic vegetation (FWP). Varies btwn ranges. Winter: willow, serviceberry, chokecherry & redosier dogwood. Spring/sum--incr. forb use (up to 70% of diet). Some pop.s use aquat. veg. overall	Often uses separate summer/winter ranges. Movements prompted by temperature & snow depth/ No hibernation	20 or more years in the wild	Males (382.5 - 531 kg); Females (270 - 360 kg)	NA	G5	S5	1977	2006	10
Mountain Cottontail (<i>Sylvilagus nuttallii</i>)	Ground	NA	Primarily dense shrubby undergrowth, riparian areas in Central and Eastern MT. In mountains, it uses shrubby gulley, and forest edges.	Herbivore	Sagebrush may be a principal food. Grasses also a preferred food. Juniper sometimes used. May prefer grasses in spring and summer	Non-migratory/No hibernation	NA	0.7 - 1.3 kg	NA	G5	S4	NA	NA	NA
Mountain lion (<i>Puma concolor</i>)	Carnivore	NA	Mostly mountains and foothills, but any habitat with sufficient food, cover and room to avoid humans. In W MT spring-fall ranges at higher elev than winter areas. Cover types in winter: 42% pole stands, 30% selectively logged (pole or mature), 18% seral brushfields	Carnivore	Deer, elk, and p. cupines most important in Montana, but may take prey ranging in size from grasshoppers to moose (FWP).	Non-migratory/NA	NA	36 - 90 kg	NA	G5	S4	1975	2007	182
Mule deer (<i>Odocoileus hemionus</i>)	Ground/Grazer	NA	Grasslands interspersed with brushy coulees or breaks; riparian habitat along prairie rivers; open to dense montane and subalpine coniferous forests, aspen groves (FWP). Varies between areas & seasons.	Herbivore	Bitterbush, mountain mahogany, chokecherry, serviceberry, grasses and forbs	Migratory in mountain-foothill habitats/ No hibernation	Normal in wild 16 years	Males (56.2 - 180 kg) Females (45 - 67.5 kg)	NA	G5	S5	1977	1978	4
Muskrat (<i>Ondatra zibethicus</i>)	Riparian	Riparian	Marshes, edges of ponds, lakes, streams, cattails, and rushes are typical habitats. An essential habitat ingredient is water of sufficient depth or velocity to prevent freezing. The presence of herbaceous vegetation, both aquatic and terrestrial, is another essential ingredient. In general, has very flexible habitat requirements and often coexists in habitats used by beavers (FWP). Lentic or slightly lotic water containing vegetation. Typha spp. (cattails) & Scirpus spp. (bulrushes) usually present. Constructs bank dens, lodges, feeding huts, platforms, pushups & canals	Herbivore	Primarily herbivorous and will eat virtually any vegetable matter. Utilizes shoots, roots, bulbs, and leaves of aquatic plants. Cattails and bulrush are preferred foods. Will also consume cultivated crops. On occasion will eat animal matter. Food is stored in the burrow or den and during winter may even eat part of its own lodge	Non-migratory/NA	NA	908 - 1,816 g	NA	G5	S5	1940	2006	3

Attachment A-3. Mammalian Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
North American Wolverine (<i>Gulo gulo</i> <i>luscus</i>)	Carnivore	Caves/Cavity /Ground/Rock	Wolverines are limited to alpine tundra, and boreal and mountain forests (primarily coniferous) in the western mountains, especially large wilderness areas. They are usually in areas with snow on the ground in winter. Riparian areas may be important winter habitat. When inactive, wolverines occupy dens in caves, rock crevices, under fallen trees, in thickets, or similar sites. Wolverine are primarily terrestrial but may climb trees. In Montana, most wolverine use in medium to scattered timber, while areas of dense, young timber were used least.	Omnivore	Wolverines are opportunistic. They feed on a wide variety of roots, berries, small mammals, birds' eggs and young, fledglings, and fish. They may attack moose, caribou, and deer hampered by deep snow. Small and medium size rodents and carrion (especially ungulate carcasses) often make up a large percentage of the diet. Prey is captured by pursuit, ambush, digging out dens, or climbing into trees. They may cache prey in the fork of tree branches or under snow	Wolverines in northwestern Montana and Alaska tend to occupy higher elevations in summer and lower elevations in winter / NA	More than 15 years in captivity	7 - 32 kg	NA	G4	S3	1938	1995	56
Northern Flying Squirrel (<i>Glaucomys sabrinus</i>)	Arboreal	Arboreal	Montane and subalpine coniferous forests. Also in riparian Cottonwood forests. Nests are constructed either within natural cavities or abandoned woodpecker holes in dead standing trees, or they are built over limbs or within witches' brooms	Omnivore	Seeds, fruits, flowers, insects, tree sap, fungus. Perhaps eggs and meat.	Non-migratory	NA	113-185 g	NA	G5	S4	1941	1969	5
Northern Pocket Gopher (<i>Thomomys talpoides</i>)	Ground	Ground- Burrows	Cultivated fields and prairie to alpine meadows. Avoids dense forests, shallow rocky soils and areas with poor snow cover.	Herbivore	underground plant parts	Non-migratory	18 to 24 months average in wild		NA	G5	S5	1966	1966	1
Pika (<i>Ochotona princeps</i>)	Ground	NA	Talus slides, boulder fields, rock rubble (with interstitial spaces adeq. for habitation) near meadows. Usually at high elevation but mid elevation possible if suitable rock cover and food plants present	Herbivore	Animals feed on hay individually, stored in small clumps under rocks, boulders.	Non-migratory/No hibernation	Maximum 7 yr	113 - 180 g	0.3-0.5 ha and mean 0.26 ha	G5	S4	1949	2006	12
Porcupine (<i>Erethizon dorsatum</i>)	Ground/ Shrub	Dens - rock crevices, trees	Common in montane forests of Western Montana, also occurs in brushy badlands, sagebrush semi-desert and along streams and rivers. Rockfall caves, ledge caves, hollow trees, or brushpiles for dens.	Herbivore	In winter uses cambium, phloem, & foliage of woody shrubs & trees--Ponderosa Pine, Lodgepole Pine, perhaps spruce & fir. In spring & summer uses reprod. parts & foliage of aspen, forbs, grasses, sedges & succulent wetland vegetation	Non-migratory. In mountainous areas seasonal altitudinal migration may occur	NA	4.5 - 12.7 kg	NA	G5	S4	1917	1966	3
Pygmy Shrew (<i>Sorex hoyi</i>)	Ground	Ground/Cavity	Dry, open coniferous forests (ponderosa pine, western larch)	Invertivore	Primarily on invertebrates	Non-migratory/NA	NA	3 - 4 g	NA	G5	S4	1978	2006	4
Raccoon (<i>Procyon lotor</i>)	Riparian	NA	Inhabits stream and lake borders near wooded areas or rocky cliffs. Most abundant in riparian and wetland habitats. Uses hollow logs, trees, and rock crevices as den sites. Forested riparian habitat--river & stream valleys. Although tree dens are most common, burrows & crevices, etc. also used.	Omnivore	Carrion, mammals, birds, reptiles, insects, amphibians, grains, nuts, and fruits.	Non-migratory / No hibernation	NA	900 - 1130 g	NA					

Attachment A-3. Mammalian Species Occuring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
Red fox (<i>Vulpes vulpes</i>)	Carnivore	Ground	Wide range of habitats. Often associated with agricultural areas. Prefers mixture of forest and open country near water. Uses dens for shelter during severe weather and when pups are being reared. Usually uses dens made by other animals. Seldom found far from permanent water. Thrive in bushy successional area where small mammals are most abundant. Occupies diverse habitats. In forest situations uses edge. Burrow den-sites comprised of sub-dens (10-40 holes). Some dens in open and some in brush.	Carnivore	Opportunistic predator that sometimes eats carrion. Preys on small mammals, birds, eggs, game birds. Varies according to avail. in W. MT. During spring: microtus spp., birds, muskrats, rabbits, grnd squirrels, deer carrion (in decreasing order of importance). In winter microtus spp., birds, N. pocket gophers. Also uses vegetation.	Non-migratory / NA	NA	18 - 31.5 kg	NA					
Red Squirrel (<i>Tamiasciurus hudsonicus</i>)	Ground	NA	Most common in Montane (Yellow Pine and Douglas Fir) and subalpine (subalpine fir-Englemann Spruce) forests in W. MT. Annual fluctuations in density are large. Correlated with size of seed and cone crops	Herbivore	Conifer cone crops, including serotinous cones. Opportunistic. Uses terminal buds, seeds, sap, berries, bark of a variety of plants. Also uses fungi. Occasionally carnivorous	Non-migratory/No hibernation	NA	198 - 250 g	NA	G5	S5	1945	2006	19
Red-tailed Chipmunk (<i>Tamias ruficaudus</i>)	Arboreal	NA	Coniferous forests, talus slides, mountains up to timberline. Most abundant in edge openings. Sometimes ranges into alpine	Herbivore	Primarily seeds and fruits. Leaves and flowers in spring, less so in summer. Occasionally uses arthropods	Non-migratory	NA	NA	NA	G5	S4	1949	1978	13
Short-tailed Weasel (<i>Mustela erminea</i>)	Carnivore	Ground-Burrows	Inhabits brushy or wooded areas, usually not far from water. Tends to avoid dense forests. Prefers areas with high densities of small mammals. Most abundant in ecotones. Mostly nocturnal but will hunt during the day. Active throughout the year. Dens in ground burrows, under stumps, rock piles, or old buildings. In Montana apparently prone to montane forest associations.	Carnivore	Weasels prey on a variety of small mammals and birds, they specialize in hunting voles. Mostly small warm-blooded vertebrates, primarily cricetidae. Hunts under snow in winter. Females generally eat smaller prey. May use invertebrates.	Non-migratory/No hibernation	NA	Males (71 - 170 g); Females (28 - 85 g)	NA	G5	S5	1939	1969	4
Snowshoe Hare (<i>Lepus americanus</i>)	Ground	NA	In W. MT, apparently preferred fairly dense stands of young pole-sized timber with some use of more open stands, openings, and edges.	Herbivore	Spring and summer: forbs and grasses. Fall and winter: more shrubs and sometimes conifer needles. Occasionally reingests feces. Sometimes eats sand	Non-migratory/No hibernation	Few live more than 3 years in the wild.	0.9 - 1.8 kg	NA	G5	S4	1986	1986	1
Southern Red-backed Vole (<i>Clethrionomys gapperi</i>)	Ground	Ground	Common in dense subalpine forests, also occurs in more open forest types, even alpine tundra. A favored prey of marten in NW MT. Populations fluctuate. Typically does not construct runways. Simple globular nests (75-100 mm. diam.), lined w/ grass, stems, leaves or moss.	Herbivore	Vegetative portions of plants, nuts, seeds, berries, mosses, lichens, ferns, fungi & arthropods	Non-migratory/NA	NA	14 - 40 g	NA	G5	S4	1949	2006	35
Striped Skunk (<i>Mephitis mephitis</i>)	Ground	Ground/Cavity	Variety of habitats including semi-open country, mixed woods, brushland, and open prairie. Most abundant in agricultural areas where there is ample food and cover. Usually absent where water table is too high for making ground dens. Forest edges, open woodland, brushy grassland, riparian vegetation, cultivated lands. Dens in ground burrows, beneath abandoned buildings, boulders, or wood, or rock piles.	Omnivore	Omnivorous, eating more animal than plant matter. Proportional composition of diet varies. Small mammals, reptiles, amphibians, berries, fruit, garbage, carrion, bird eggs, & arthropods.	Non-migratory / No hibernation	NA	2.7 - 6.3 kg	NA	G5	S5	1895	1999	3
Vagrant Shrew (<i>Sorex vagrans</i>)	Ground	NA	At elevations below 5000 ft, usually Doug. Fir, Lodgepole Pine, W. Larch, Grand Fir, W. Red Cedar forests. Often found in moist sites. Marshes, bogs, wet meadows, and along streams in forests. Uses echolocation to orient in darkness.	Carnivore	Insects, annelida, shrews, vegetable matter, insect larvae. Also uses plant seeds, carrion, and some mushrooms	Non-migratory/NA	Few live more than 16 months.	7 g	NA	G5	S4	1895	2006	39

Attachment A-3. Mammalian Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	Habitat Group		General Habitat Description	Feeding Guild	Food	Migration/ Hibernation	Longevity	Size	Home Range	Global Rank	State Rank	Observation in Lincoln, Co.,		
	Foraging	Breeding, Resting										Oldest	Most Recent	Number
Water Shrew (<i>Sorex palustris</i>)	Riparian	Ground	Streamside habitat in coniferous forests, particularly in or under overhanging banks or crevices--good cover. However, also found in seasonal streams and small seeps. Also above timberline. Nests of dried sticks and leaves.	Invertivore	Aquatic insect larvae, also some vegetable matter, oligochaetes, other shrews, arachnids, and small fish	Non-migratory/NA	NA	9 - 14 g	NA	G5	S4	1966	1992	4
Water Vole (<i>Microtus richardsoni</i>)	Riparian	Ground-Burrows	Semi-aquatic. Near streams & lakes in subalpine and alpine zones. Normally above 5000 ft. in western mountains. Moist grass & sedge areas, streamside hummocks overhung w/ willows. Burrows, runways & cuttings are conspicuous in summer	Omnivore	Possible heavy use of graminoids. Composite data from a variety of areas suggest forbs & willows also eaten. Use of vaccinium, erythronium bulbs, conifer seeds, insects	Non-migratory/NA	NA	71 - 100 g	NA	G5	S4			
Western Jumping Mouse (<i>Zapus princeps</i>)	Ground	Ground	tall grass along streams, with or without a brush or tree canopy. Also dry grasslands in N. Central MT. Mesic forests with sparse understory herbage in W. MT. From valley floors to timberline & alpine wet sedge meadows. Nests are in mounds or banks elevated above surrounding ground (well-drained) usually 2 feet underground, shredded vegetation insulative core.	Herbivore	Seeds	Non-migratory/Hibernates	As long as 6 years in wild if survive first hibernation (half of all juveniles die during first hibernation)	18 to 37 grams	NA	G5	S4	1949	2006	17
White-tailed deer (<i>Odocoileus virginianus</i>)	Ground/Grazer	NA	River and creek bottoms; dense vegetation at higher elevations; sometimes open bitterbrush hillsides in winter (FWP). In W MT mature subclimax coniferous forest, cool sites, diversity & moist sites important in summer (Leach 1982). In winter prefer dense canopy classes, moist habitat types, uncut areas & low snow depths (Berner 1985).	Herbivore	Leaves, twigs, fruits, and berries of browse plants such as chokecherry, serviceberry, snowberry, and dogwood; some forbs during summer (FWP). Browse most imp. statewide - yr. round, particularly so in winter. Graminoid use increases in spring, forb use in late spring & sometimes in fall.	Uses summer range, winter range in W MT may be 8.69-15 mi. apart.	Up to 16.5 years in the wild.	Males (33.7 - 180 kg); Females (22.5 - 112.5 kg)	NA	G5	S5	1978	2006	3
Yellow pine chipmunk (<i>Tamias amoenus</i>)	Ground	Ground-Burrows	Open stands of ponderosa pine and Douglas fir. Nest chamber in burrow averaging 11 inches below surface. Open coniferous forests, chaparral, rocky areas with brush or scattered bines, burned over areas.	Herbivore	Fruits and seeds and a few insects	Non-migratory/Hibernates	5 years or more in the wild	38 - 71 gram	NA	G5	S5	1860	2006	10
Yellow-bellied Marmot (<i>Marmota flaviventris</i>)	Ground/Rock Slopes	Dens - Talus slopes, rock outcrops	Semi-fossorial. Inhabits talus slopes or rock outcrops in meadows. Abundant herbaceous & grassy plants nearby. Rocks support burrows & serve as sunning & observ. posts. Avoids dense forests. Rarely in holl riv bot fld pln c-wood trees. Occurs from valley bottoms to alpine tundra where suitable habitat exists. Where <i>Marmota caligata</i> occurs, <i>M. flavi-</i> ventris is restricted to lower elevations.	Herbivore	Grasses, flowers, forbs--in late summer eats seeds. Mode- rate grazing by ungulates may favor marmots. Likes alfalfa	Non-migratory, although dispersal movements may be observed/Hibernates	NA	2.2 - 4.5 kg	NA	G5	S4	1949	1949	3

Attachment A-4. Fish Species Occuring within the Libby OU3 Site
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Common Name (Genus/species)	General Habitat Description	Food Habits	Global Rank	State Rank	Observation in Lincoln, Co., Montana		
					Oldest	Most Recent	Number
Black Bullhead (<i>Ameiurus melas</i>)	Turbid, mud bottomed lakes and ponds; also pools and backwaters of streams. Tolerates high water temperatures and low levels of dissolved oxygen.	Omnivorous. Mostly aquatic insects, crustaceans, mollusks, fish, and vegetation matter. Young feed during day, while adults feed at night.	G5	SNA	1996	1996	1
Brook Trout (<i>Salvelinus fontinalis</i>)	Prefers small spring fed streams and ponds with sand or gravel bottom and vegetation. Clear, cool water. Spawns over gravel in either streams or lakes with percolation/spring areas in lakes.	Feed mainly on aquatic insects and other small aquatic invertebrates throughout life. Larger individuals may eat small fish	G5	SNA	1960	2006	86
Brown Trout (<i>Salmo trutta</i>)	Valley portions of larger rivers where gradients are low and Summer temperatures range from 60-70 degrees F. Also reservoirs and lakes at similar elevation with suitable spawning trib.	Feeds largely on underwater aquatic insects. Also uses many other small organisms available and large individuals eat many small fish	G5	SNA	2006	2006	2
Bull Trout (<i>Salvelinus confluentus</i>)	Sub-adult and adult fluvial bull trout reside in larger streams and rivers and spawn in smaller tributary streams, whereas adfluvial bull trout reside in lakes and spawn in tributaries. They spawn in headwater streams with clear gravel or rubble bottom.	Young feed on aquatic insects. The adults are piscivorous.	G3	S2	1960	2004	40
Burbot (<i>Lota lota</i>)	Large rivers and cold, deep lakes and reservoirs. Spawn in shallow water, usually in rocky areas.	Young feed on aquatic invertebrates. Adults are piscivorous	G5	SNA	1993	1993	1
Channel Catfish (<i>Ictalurus punctatus</i>)	Prefers large rivers and lowland lakes. Thrives at water temperatures above 70 degrees. Tolerates turbid water.	Omnivorous feeder. Uses almost any living or dead organisms available.	G5	S5	2006	2006	1
Common Carp (<i>Cyprinus carpio</i>)	Primarily lakes and reservoirs, moderately warm water and shallows. Also rivers, pools and backwaters. Congregates in areas of organic enrichment. Tolerates turbid water and low dissolved oxygen; avoids cold and swift, rocky streams. Spawns in shallow weedy areas	An omnivorous feeder with vegetation and detritus making up bulk of diet. May feed on any available aquatic organism including eggs.	G5	SNA	2006	2006	2
Fathead Minnow (<i>Pimephales promelas</i>)	Habitat is highly variable but found mostly in small turbid creeks and shallow ponds of flatlands. Very tolerant of extreme conditions found in a prairie environment (turbid water, high temperature, and low dissolved oxygen).	Variety of minute aquatic plants and animals.	G5	S4S5	1998	1998	1
Kokanee Salmon (<i>Oncorhynchus nerka</i>)	Cold, clear lakes and reservoirs and Kokanee Salmon are found at all depths. They spawn over loose rubble, gravel, and sand in lower portions of tributary streams or along lake shores	The diet consists mostly of plankton. Micro-crustacea are most important, but midges and other aquatic insects are often taken	G5	SNA	2002	2002	1
Largescale Sucker (<i>Catostomus macrocheilus</i>)	Found in both streams and lakes. Spawns in gravel riffles with strong current or along lake margins	Almost any available organism found on the substrate	G5	S5	1993	2003	3
Longnose Dace (<i>Rhinichthys cataractae</i>)	Habitat variable. Found in lakes, streams, springs. Preferred habitat is riffles with a rocky substrate	Eats mostly immature aquatic insects picked off the rocks. Small amounts of algae and a few fish eggs are also eaten	G5	S5	2000	2006	8
Longnose Sucker (<i>Catostomus catostomus</i>)	Cold, clear streams and lakes; sometimes moderately warm waters and turbid waters. Spawns over loose gravel beds in riffle areas.	Considerable algae, midge larvae, and most aquatic invertebrates	G5	S5	1996	2006	3
Mottled Sculpin (<i>Cottus bairdi</i>)	Prefer riffle areas of fast-flowing streams that are clear and have rocky bottoms.	Variety of immature aquatic organisms, but midge and addis larvae are by far the most important. A study in southwest Montana showed bottom-dwelling aquatic insects comprising 99.7% of the diet.	G5	S5	1953	1991	5
Mountain Whitefish (<i>Prosopium williamsi</i>)	Medium to large cold mountain streams. Also found in lakes and reservoirs. Normally a stream spawner in riffles over gravel or small rubble but has been seen spawning along lake shorelines.	Mostly on aquatic insects but also takes terrestrial insects which fall into water. May eat fish eggs, but rarely fishes. Feeds actively in Winter. Zooplankton important in lakes.	G5	S5	1969	2006	14

Attachment A-4. Fish Species Occurring within the Libby OU3 Site
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Common Name (Genus/species)	General Habitat Description	Food Habits	Global Rank	State Rank	Observation in Lincoln, Co., Montana		
					Oldest	Most Recent	Number
Northern Pikeminnow (<i>Ptychocheilus oregonensis</i>)	Prefers lakes and slow - flowing streams of moderate size. Young usually school in shallow water near lake shores and in quiet backwaters of streams	Most kinds of aquatic invertebrates. Adults frequently eat small fish. Considered a serious predator on young salmon and trout	G5	S5	1952	2006	3
Peamouth (<i>Mylocheilus caurinus</i>)	Shallow weedy zones of lakes or rivers.	Young feed mainly on micro-crustaceans. Adults eat micro-crustaceans, snails, adult aquatic and terrestrial insects. Occasionally small fish.	G5	S5	2006	2006	1
Rainbow Trout (<i>Oncorhynchus mykiss</i>)	Cool clean streams, lakes, res., farm ponds. Able to withstand wider range of temperatures than most trout. Spawns in streams over gravel beds.	Feed mainly on aquatic insects but eat what is available to them. Large adults also eat fish. River populations mostly insect eaters while zooplankton and forage fish are important in Lake Kootcanusa.	G5	S5	1976	2006	80
Redside Shiner (<i>Richardsonius balteatus</i>)	Lakes, ponds, and larger rivers where current is weak or lacking.	Young feed mainly on plankton and adults eat mostly aquatic insects and snails.	G5	S5	2002	2006	4
River Carpsucker (<i>Carpodacus carpio</i>)	Reservoirs and the pools and backwaters of rivers. Spawn in larger streams with backwater areas.	Mostly diatoms, desmids, and filamentous algae. Also aquatic invertebrate larvae.	G5	S5	2006	2006	1
Slimy Sculpin (<i>Cottus cognatus</i>)	Rocky riffles of cold, clear streams, but it is sometimes found along the rubble beaches of lakes, especially near the mouths of inlet streams	Mostly immature aquatic insects and invertebrates, but also includes any small fish available	G5	S5	1950	2006	58
Smallmouth Bass (<i>Micropterus dolomieu</i>)	Prefers clear cool water and rocky substrates in both rivers and lakes. In streams, it prefers riffle areas with clean bottoms. In lakes, it prefers rocky shorelines, reefs, out- croppings, gravel bars, etc.	Feeds on most available item. Fry feed on zooplankton and small mayflies. Adults feed heavily on fish, frogs, and aquatic invertebrates. Seems to prefer crayfish, if available.	G5	SNA	2006	2006	2
Torrent Sculpin (<i>Cottus rhotheus</i>)	Riffles of cold, clear streams, but are also taken in lakes. They hide near stones on the bottom.	The fry eat mostly plankton. Adults feed mainly on aquatic insects and a variety of invertebrates, but also include plankton. Larger individuals often eat small fish.	G5	S3	1950	2006	89
Westslope Cutthroat Trout (<i>Oncorhynchus clarkii lewisi</i>)	Spawning and rearing streams tend to be cold and nutrient poor. Seek gravel substrate in riffles and pool crests for spawning. Sensitive to fine sediment. Require cold water. Thrive in streams with more pool habitat and cover than uniform, simple habitat. Juveniles overwinter in the interstitial spaces of large stream substrate. Adult need deep, slow moving pools that do not fill with anchor ice in order to survive the winter.	NA	G4T3	S2	1960	2006	60
White Sturgeon - <i>Acipenser transmontanus</i>							

Data are taken from: <http://fieldguide.mt.gov/>

Montana Species Ranking Codes: Montana employs a standardized ranking system to denote global (G - range-wide) and state status (S) (NatureServe 2003). Species are assigned numeric ranks ranging from 1 (critically imperiled) to 5 (demonstrably secure), reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks - the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat.

G1 S1

At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.

G2 S2

At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to global extinction or extirpation in the state.

G3 S3

Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas.

G4 S4

Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern.

G5 S5

Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.

Attachment A-5. Reptile Species Occuring within the Libby OU3 Site
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Common Name (Genus/species)	General Habitat Description	Food Habits	Global Rank	State Rank	Observation in Lincoln, Co., Montana		
					Oldest	Most Recent	Number
Common Gartersnake (<i>Thamnophis sirtalis</i>)	Found in nearly all habitats, but most commonly at lower elevations around water. Prefer moist habitats and are found most often along the borders of streams, ponds and lakes. They may travel long distances (4 to 17 kilometers) from hibernacula to forage in preferred habitat	Variety of vertebrates and invertebrates.	G5	S4	1954	2006	55
Eastern Racer (<i>Coluber constrictor</i>)	Associated with relatively open habitats either in shortgrass prairie or forested areas. Very fast and active. prey on insects and small vertebrates such as mice and frogs. Females lay a clutch of three to seven eggs in summer. In the NW racers generally absent from dense forest/hi mtns.	Orthopterans can form a major part of diet and have been re-ported as food in NC MT. Small mammals, lizards, orthopterans, anurans are all major components of diet.	G5	S5	1991	1991	4
Gophersnake (<i>Pituophis catenifer</i>)	Dry habitats, including open pine forests. Occasionally climb trees.	Rodents, rabbits, ground-dwelling birds, and to a lesser extent lizards.	G5	S5	1993	1994	3
Northern Alligator Lizard (<i>Elgaria coerulea</i>)	Little specific information on habitat associations in Montana. South-facing slopes in fine to coarse talus, sometimes in the open, but often with some canopy cover of Douglas-fir, ponderosa pine, a variety of shrubby species (serviceberry, ninebark, mock orange), and a litter layer of dried leaves and conifer needles.	An invertivore, northern alligator lizards feed on insects, ticks, spiders, centipedes, millipedes, slugs and snails.	G5	S3	1949	2006	12
Painted Turtle (<i>Chrysemys picta</i>)	NA (web page not available)	NA (web page not available)	G5	S4	1955	2006	44
Rubber Boa (<i>Charina bottae</i>)	Usually found under logs and rocks in either moist or dry forest habitats. They are primarily nocturnal, but occasionally may be observed sunning on roads, trails, or in open areas.	Feed primarily on small mice but also take shrews, salamanders, snakes, and lizards.	G5	S4	1980	2004	15
Terrestrial Gartersnake (<i>Thamnophis elegans</i>)	Found in nearly all habitats, but most commonly at lower elevations around water. Common near water but also found away from water. At high elev. common on rocky cliffs/ brushy talus.	They eat a variety of vertebrates and invertebrates.	G5	S5	1952	2006	51

Data are taken from: <http://fieldguide.mt.gov/>

Montana Species Ranking Codes: Montana employs a standardized ranking system to denote global (G - range-wide) and state status (S) (NatureServe 2003). Species are assigned numeric ranks ranging from 1 (critically imperiled) to 5 (demonstrably secure), reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks - the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat.

G1 S1

At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.

G2 S2

At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to global extinction or extirpation in the state.

G3 S3

Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas.

G4 S4

Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern.

G5 S5

Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.

Attachment A-6. Invertebrate Species Occuring within the Libby OU3 Site
Page 31 of 32

Common Name (Genus/species)		General Habitat Description	Global Rank	State Rank	Observation in Lincoln, Co., Montana		
					Oldest	Most Recent	Number
Freshwater Sponge (<i>Heteromeyenia baileyi</i>)	Aquatic	NA	G5	S1S3	1997	1997	1
Stonefly (<i>Utacampia columbiana</i>)	Aquatic	The larvae occur on the upper surfaces and sides of cobbles and boulders in moderate gradient, fast flowing, foothills to mountain streams. Inhabits streams with more intermediate characteristics between the higher elevation, cold mountain streams (more likely to find Glossosoma & Anagapetus), and the large warmer transitional rivers downstream (more likely to find Prototila). Generally the riparian canopy of the occupied streams is mostly (>50%) open, and less shaded than mountain streams. In clear streams and rivers during low flows, it is typical to be able to locate & identify <i>Agapetus</i> larvae on the tops of rocks. In relation to trophic status, A. montanus larvae scrape, graze and digest algae and diatoms from the surfaces of rocks.	G4	S2			1
Banded Tigersnail (<i>Anguispira kochi</i>)	Terrestrial	NA	G5	SNR	2005	2007	39
Blue Glass (<i>Nesovitrea binneyana</i>)	Terrestrial	NA	G5	SNR	2007	2007	7
Brown Hive (<i>Euconulus fulvus</i>)	Terrestrial	NA	G5	SNR	2005	2007	17
Coeur d'Alene Oregonian (<i>Cryptomastix mullani</i>)	Terrestrial	NA	G4	SNR	2005	2007	20
Land Snail, Cross Vertigo (<i>Vertigo modesta</i>)	Terrestrial	NA	G5	SNR	2006	2007	5
Land Snail, Fir Pinwheel (<i>Radiodiscus abietum</i>)	Terrestrial	NA	G4	S2S3	1959	2007	32
Land Snail, Forest Disc (<i>Discus whitneyi</i>)	Terrestrial	NA	G5	SNR	2005	2007	12
Slug, Giant Gardenslug (<i>Limax maximus</i>)	Terrestrial	Common in gardens and buildings, and margins of native forests, does not seem to penetrate far into undisturbed forests, although it can be abundant in modified forest remnants and secondary forests. This nocturnal slug feeds primarily on decaying plant material and fungi, but because it shows aggressive behavior towards other slugs, it is often erroneously regarded as a predator	G5	SNA	2005	2005	1
Slug, Gray Fieldslug (<i>Deroceras reticulatum</i>)	Terrestrial	NA	G5	SNA	2007	2007	1
Land snail, Hedgehog Arion (<i>Arion intermedius</i>)	Terrestrial	Often locally abundant in pastures, hedgerows, plantation forests, and in native forests. It can penetrate deep into undisturbed forest from areas disturbed by humans	G5	SNR	2007	2007	3
Land snail, Idaho Forestsnail (<i>Allogona pychophora</i>)	Terrestrial	NA	G5	SNR	2005	2007	15
Slug, Magnum Mantleslug (<i>Magnipelta mycophaga</i>)	Terrestrial	Low- to mid-elevation sites, often with water in the general vicinity. Moist, cool sites in relatively undisturbed forest with an intact duff layer, such as are found in moist valleys, ravines, and talus areas, are preferred. Forest canopy composition at sites includes <i>Picea engelmannii</i> , <i>Pseudotsuga menziesii</i> , <i>Pinus ponderosa</i> , <i>Pinus albicaulis</i> , <i>Larix occidentalis</i> , <i>Abies lasiocarpa</i> , and <i>Abies grandis</i> , often with <i>Alnus</i> present; spruce-fir appears to be the most frequent forest association. Often found on the ground under pieces of loose bark, logs, loose stones, and in rotted wood; surface active on cool (10-16 wet and overcast days, probably most active at night.	G3	S1S3	2005	2007	8
Slug, Meadow Slug (<i>Deroceras laeve</i>)	Terrestrial	Cliff, Cropland/hedgerow, Forest - Conifer, Forest - Hardwood, Forest - Mixed, Forest Edge, Forest/Woodland, Grassland/herbaceous, Old field, Savanna, Shrubland/chaparral, Suburban/orchard, Urban/edificarian, Woodland - Conifer, Woodland - Hardwood, Woodland - Mixed	G5	SNA	2005	2007	5
Land snail, Multitrib Vallonia (<i>Vallonia gracilicosta</i>)	Terrestrial	NA	G5Q	SNR	2007	2007	1
Land snail, Orange- banded Arion (<i>Arion fasciatus</i>)	Terrestrial	Damp areas and wet meadows adjacent to streams	GNR	SNR	2007	2007	3

Attachment A-6. Invertebrate Species Occuring within the Libby OU3 Site
Page 32 of 32

Common Name (Genus/species)		General Habitat Description	Global Rank	State Rank	Observation in Lincoln, Co., Montana		
					Oldest	Most Recent	Number
Darner damselfly, Paddle-tailed Darner (<i>Aeshna palmata</i>)	Terrestrial	Found in most habitats, including warm springs; found far from water	G5	S5	1994	1994	1
Slug, Pale Jumping-slug (<i>Hemphillia camelus</i>)	Terrestrial	NA	G4	S1S3	2005	2007	10
Slug, Pygmy Slug (<i>Kootenaia burkei</i>)	Terrestrial	Forest - Mixed, Fallen log/debris, forested and adjacent to a perennial water body. Found on forest floor mostly, either on or under woody debris, mats of moss, or deciduous tree leaves; two specimens collected 0.2 m aboveground on moss-covered tree trunk along stream edge	G2	S1S2	2005	2007	17
Land Snail, Quick Gloss (<i>Zonitoides arboreus</i>)	Terrestrial	NA	G5	SNR	2005	2007	26
Land Snail, Robust Lancetooth (<i>Haplotrema vancouverense</i>)	Terrestrial	NA	G5	S1S2	2006	2006	16
Land Snail, Rocky Mountainsnail (<i>Oreohelix strigosa</i>)	Terrestrial	Composition of the plant community appears to be of little importance, dominant plant species ranges from sagebrush to a wide variety of deciduous shrubs and trees and a similarly wide variety of coniferous shrubs and trees. Substrate, however, is of great importance, the presence of exposed limestone being almost critical for occurrence; exceptions, however, are well known, there being documented occurrences on sandstone, and occurrences on other substrates probably exist. Slope, too, has been considered to be of importance. Herbivorous.	G5	SNR	2005	2006	6
Slug, Sheathed Slug (<i>Zacoleus idahoensis</i>)	Terrestrial	Moist microsites in relatively intact <i>Pseudotsuga menziesii</i> , <i>Pinus ponderosa</i> , and <i>Picea engelmannii</i> forests in moist valleys, ravines, and talus on both north- and south-facing slopes. Meadows and cedar swamps, white pine stands, spruce valleys, rockslides, and near springs.	G3G4	S2S3	1959	2007	18
Land Snail, Smoky Taildropper (<i>Prophysaon humile</i>)	Terrestrial	NA	G3	S1S3	2005	2007	22
Land Snail, Spruce Snail (<i>Microphysula ingersolli</i>)	Terrestrial	NA	G4G5	SNR	2005	2007	29
Land Snail, Striate Disc (<i>Discus shimekii</i>)	Terrestrial	Found most often in litter in rich lowland forest, generally on shaded, north-facing slope bases, often bordering or ranging slightly onto stream floodplain. Usually on limestone soils. Species will crawl on downed wood and is sometimes seen on rock surfaces. Primarily feeds on partially decayed deciduous tree leaves and degraded herbaceous vegetation.	G5	S1	1959	1959	1
Land Snail, Subalpine Mountainsnail (<i>Oreohelix subrudis</i>)	Terrestrial	NA	G5	SNR	2007	2007	6
Western Pearlshell (<i>Margaritifera falcata</i>)	Aquatic	Cool-coldwater running streams that are generally wider than 4 m, perferable habitat is stable sand or gravel substrates. Found in hard as well as soft water. This species occurs in sand, gravel and even among cobble and boulders in low to moderate gradient streams up to larger rivers.	G4	S2S4	1992	1996	7

Data are taken from: <http://fieldguide.mt.gov/>
Inc

G1 S1

At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.

G2 S2

At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to global extinction or extirpation in the state.

G3 S3

Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas.

G4 S4

Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern.

G5 S5

Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.

DRAFT - FOR BTAG REVIEW AND DISCUSSION ONLY

ATTACHMENT B

PHASE I RESULTS

See electronic file entitled "Attachment B.xls"

ATTACHMENT B

ANALYTICAL RESULTS OF PHASE I SAMPLING-RAW DATA

Table B-1. Surface Water Results by Station

Table B-2. Summary Statistics for Surface Water Results by Reach

Table B-3. Summary Results of Detected Analytes in Surface Water by Station

Table B-4. Sediment Results by Station

Table B-5. Summary Statistics for Sediment Results by Reach

Table B-6. Summary Results of Detected Analytes in Sediment by Station

Table B-7. Soil Results by Station

Table B-8. Summary Statistics for Soil Results by Reach

Table B-9. Summary Results of Detected Analytes in Soil by Station

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Center at (303) 312-6473.

TABLE 8.1. NON-HAZARDOUS SURFACE WATER SAMPLES COLLECTED AT LBSR DURING PHASE I

STATION	WATER BODY	DATE	TIME	TEMP	ANALYSIS										RESULTS												REMARKS
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TABLE B-2. SUMMARY STATISTICS FOR ABBOTSDON SURFACE WATER BY REACH LENGTH OF PUARE

TABLE B-4. WOV ASBESTOS RESULTS FOR SEDIMENT SAMPLES COLLECTED AT LEBBY GUT DURING PHASE I

[illegible]

TABLE 10-3. SUMMARY STATISTICS NONABSTENTION SEDIMENT RESULTS BY REACH LENGTH (M) PHASE

[illegible]

Non-steroids are listed at 177 for domestic use.
NA is also quoted.

TABLE B-6. NONASBESTOS DETECTED ANALYTE SEDIMENT RESULTS LIBBY OUS PHASE 1

Category	Method	Analyte	Units	UPPER RAINY CREEK		TAILINGS IMPOUNDMENT		MILL POND		LOWER RAINY CREEK					FLEETWOOD CREEK			CARNEY CREEK			SEEPS							
				URC-1	URC-2	TP	TP-TOE1	TP-TOE2	MP	LRC-1	LRC-2	LRC-3	LRC-4	LRC-5	LRC-6	FC-2	FC-POND	FC-1	CC-9	CC-1	CCS-9	CCS-8	CCS-6	CCS-4	CCS-11	CCS-14	CCS-16	
Metals	SW6020 & SW6010B	Aluminum	mg/kg-dry	6870	12300	11200	4730	11300	11200	10000	9690	16200	3460	11200	11200	9240	26100	27500	4670	6630	10400	33800	13600	9290	16100	12200	9180	
		Arsenic	mg/kg-dry	3	3	3	7	ND	6	ND	ND	ND	ND	ND	ND	ND	2	3	ND	ND	2	5	ND	ND	ND	ND	3	
		Barium	mg/kg-dry	284	302	906	1120	637	703	440	397	1080	186	543	855	219	1520	431	685	199	516	4930	391	322	583	2680		
		Chromium	mg/kg-dry	6	32.8	110	43	213	48	148	135	233	38.8	129	126	21	289	14.6	43.3	77.2	216	988	180	165	109	123	93	
		Cobalt	mg/kg-dry	ND	9	17	26	20	11	13	13	24	6	13	19	9	42	7	7	13	16	75	21	17	16	17	27	
		Copper	mg/kg-dry	19	37	29	16	21	49	15	23	36	13	22	36	25	66	27	37	18	64	57	36	35	16	14	29	
		Iron	mg/kg-dry	5120	17600	16200	14500	27000	14000	15700	14900	27800	9880	20700	33200	22300	39600	18300	10600	20900	16900	46400	18100	19000	25100	54600		
		Lead	mg/kg-dry	7	12	19	11	100	15	7	9	22	ND	11	33	9	48	18	12	7	96	56	89	33	14	9	7	
		Manganese	mg/kg-dry	306	346	392	12700	2470	953	299	785	798	301	493	492	151	573	302	2920	263	332	1120	419	162	146	168	2860	
		Nickel	mg/kg-dry	ND	14	32	34	41	17	26	27	48	9	36	31	11	82	12	11	26	40	226	43	37	28	34	39	
		Selenium	mg/kg-dry	1.2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7	ND	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND
		Thallium	mg/kg-dry	ND	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	ND	ND	ND	ND	4.3	ND	ND	ND	ND	ND	ND
		Vanadium	mg/kg-dry	6	29	26	46	79	31	31	31	58	27	48	80	45	58	23	35	48	62	105	41	35	45	53	57	
		Zinc	mg/kg-dry	15	35	29	17	19	19	19	20	34	9	25	26	23	50	42	15	48	23	54	24	17	31	15	19	
	SW7470A	Mercury	mg/kg-dry	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
VOC	SW8260B	Methyl acetate	mg/kg-dry	NA	NA	NA	NA	0.24	NA	NA	0.17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
PAH	SW8370C	Pyrene	mg/kg-dry	ND	ND	ND	NA	0.0049	ND	NA	ND	ND	NA	NA	ND	ND	ND	NA	NA	ND	NA	ND	NA	ND	NA	ND		
Extractable Hydrocarbons	MA-EPH	C11 to C22 Aromatics	mg/kg-dry	ND	96	436	NA	NA	56	NA	NA	ND	NA	NA	ND	ND	72	NA	NA	ND	NA	ND	NA	NA	ND	NA	ND	
		C19 to C36 Aliphatics	mg/kg-dry	ND	124	350	NA	NA	69	NA	NA	ND	NA	NA	ND	ND	201	NA	NA	ND	NA	ND	NA	NA	ND	NA	ND	
		C9 to C18 Aliphatics	mg/kg-dry	ND	ND	162	NA	NA	ND	NA	NA	ND	NA	NA	ND	ND	36	NA	NA	ND	NA	ND	NA	NA	ND	NA	ND	
	SW8015M	Total Extractable Hydrocarbons	mg/kg-dry	ND	335	1240	NA	NA	176	NA	NA	ND	NA	NA	ND	ND	405	NA	NA	ND	NA	ND	NA	NA	ND	NA	ND	
Volatile Hydrocarbons	MA-VPH	Total Extractable Hydrocarbons	mg/kg-dry	ND	335	1240	NA	NA	176	NA	NA	ND	NA	NA	ND	ND	405	NA	NA	ND	NA	ND	NA	NA	ND	NA	ND	
		C9 to C10 Aromatics	mg/kg-dry	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		C9 to C12 Aliphatics	mg/kg-dry	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2	ND	ND	
		Total Purgeable Hydrocarbons	mg/kg-dry	12	ND	17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.2	ND	ND	
Anions	E300.0	Fluoride ¹	mg/kg-dry	ND	ND	1.5	1.7	ND	4.1	ND	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND	2.9	ND	ND	ND	ND	ND		
	F365.1	Total Phosphorus ¹	mg/kg-dry	408	1350	4250	2580	1740	3120	2630	1400	4980	1470	2240	3520	3140	3220	2150	2190	2480	1470	361	600	1140	1680	3010		
Sediment Quality Parameters	ASAM10-3.2	pH, sat. paste	s.u.	7.1	7.1	6.7	7.1	7	6.3	8.2	7.8	7.6	7.8	7.7	7.4	7.1	6.9	7.2	7.5	7.6	7	6.8	7.1	7.3	7.4	6.9	7	
	SW1550A	Moisture	wt%	75	45	77	18	15	75	21	19	39	26	20	29	44	70	32	32	18	22	86	31	28	39	48	44	
	Leon	Carbon, Organic	wt%	15.4	2.05	6.76	1.24	0.42	5.47	1.78	0.35	0.61	1.07	2.65	1.15	1.82	2.28	1.21	2.98	0.38	0.45	3.67	0.7	0.22	0.81	5.41	0.97	

ND = not detected

NA = not analyzed

¹Data not yet validated

TABLE B-8. NON-AQUEOUS DILUTED ANALYTE SOIL RESIDUE LENGTHY PHASE

[illegible]

*Data not yet analyzed

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ATTACHMENT C

Toxicity Screening Benchmarks – Non-Asbestos Contaminants

ATTACHMENT C SELECTION OF TOXICITY BENCHMARKS

Overview

The hazard quotient approach to risk characterization is based on comparison of site-related indices of exposure to appropriate benchmarks of toxicity. These benchmarks are concentration-based (e.g., the concentration in soil, sediment, surface water, or diet). Each benchmark is contaminant-specific, receptor-specific and is usually medium-specific.

For this initial screening assessment of Phase I results, all toxicity benchmarks are based on values developed by various regulatory agencies and published in the literature. This attachment describes the various sources of benchmark values reviewed, and identifies the hierarchy used to prioritize values when more than one value was available.

This appendix is organized into the following sections:

Aquatic Receptors

- C-1 Surface Water Benchmarks for Aquatic Receptors
- C-2 Surface Water Benchmarks for Hardness-Dependent Metals
- C-3 Sediment Benchmarks for Benthic Macroinvertebrates

Terrestrial Receptors

- C-4 Soil Benchmarks for Plants and Soil Invertebrates

Wildlife Receptors

- C-5 Risk-Based Concentrations for Birds and Mammals

Aquatic Receptors (Fish & Benthic Macroinvertebrates)

C-1 & C-2 Surface Water Benchmarks for Aquatic Receptors

Toxicity values for the protection aquatic life from contaminants in surface water are available from several sources. Each of these sources is described briefly below.

National Ambient Water Quality Criteria

The USEPA has established acute and chronic National Ambient Water Quality Criteria (NAWQC) values for surface waters for the protection of aquatic communities (USEPA 2002a). The acute NAWQC is intended to protect against short-term (48 to 96 hour) lethality, while the chronic NAWQC is intended to protect against long-term effects on growth, reproduction, and survival. The NAWQC values are not species-specific, but are designed to protect 95% of the aquatic species for which toxicity data are available (USEPA 1985).

Great Lake Water Quality Initiative Tier II Values

The approach used for the derivation of Great Lake Water Quality Initiative (GLWQI) Tier II secondary acute values (SAVs) and secondary chronic values (SCVs) is similar to that used to derive NAWQC. Data and detailed methods are described in Appendix B of Suter and Tsao (1996). In brief, a secondary acute value is derived by taking the lowest genus mean acute value (GMAV) and dividing it by the Final Acute Value Factor (FAVF). The FAVF is based on the number of studies and types of species used to derive the FAV. Once an SAV is calculated, the geometric mean of each of the secondary acute-chronic ratios (SACR) is found. The SCV is calculated by dividing the SAV by the SACR.

USEPA Region 4 Screening Values

Screening level freshwater benchmarks are also available from USEPA Region 4 (USEPA, 2002b). The Region 4 acute and chronic screening values are equal to the lowest effect level (LEL) divided by 10 to protect for sensitive species. If no chronic LEL is available, the chronic screening value is equal to the lowest acute LC50 or EC50 divided by 10.

Canadian Water Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) have established water quality guidelines (WQG) for the protection of aquatic life in Canadian waters (CCME, 1991, 2001). The protocol for deriving water quality guidelines is similar to the NAWQC procedure. Protocol details are available on the CCME WQG website. In brief, the guideline is equal to the most sensitive LOEL from a chronic exposure study divided by a safety factor of 10. If a chronic LOEL is not available, the WQG is equal to

the acute LC50 divided by the acute/chronic ratio (ACR). The CCME WQG is designed to be protective of "100% of the aquatic life species, 100% of the time".

Oak Ridge National Laboratory Lowest Chronic Values and EC20 Values

Oak Ridge National Laboratory (ORNL) has compiled summary tables of the lowest chronic values (LCVs) in surface water for fish, daphnids, non-daphnid invertebrates, aquatic plants, and aquatic populations (Suter and Tsao, 1996). In some instances, the LCVs were extrapolated from LC50 and EC50 data using fish and daphnid-specific equations. ORNL also summarized EC20 data for fish, daphnids, sensitive species, and aquatic populations. The EC20s are based on a level of biological effect and are intended to be indices of population production (Suter and Tsao, 1996).

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 has derived ecological screening levels (ESLs) for RCRA Appendix IX Hazardous Constituents in soil, surface water, sediment, and air (USEPA 1999). The surface water ESL is based on either an aquatic benchmark, which is protective of direct contact exposures, or a wildlife receptor-specific benchmark, which is protective of ingestion exposures in the mink and belted kingfisher. The surface water ESL does not distinguish whether it is derived based on aquatic or wildlife exposure.

OSWER Ecotox Thresholds

The OSWER Ecotox Thresholds (ETs) were presented in a USEPA ECO Update Bulletin (USEPA, 1996). The bulletin provided an overview of the development and use of ecological benchmarks for surface water and sediment. For surface water, the ET is based on either the chronic NAWQC or the GLWQI Tier II value.

Because the USEPA Region 5 ESLs do not make a distinction between surface water benchmarks derived from aquatic data and wildlife data, these values are excluded from consideration as a benchmark source. The OSWER ETs were also excluded because they are based on primary sources (NAWQC, GLWQI Tier II) that had been previously reviewed. For the remaining sources, selection of the surface water toxicity benchmarks for aquatic receptors was based on the following hierarchy:

- National Ambient Water Quality Criteria
- Great Lake Water Quality Initiative Tier II Values
- USEPA Region 4 Screening Values
- Canadian Water Quality Guidelines
- Oak Ridge National Laboratory LCVs and EC20s

For many metals and metalloids, the NAWQC values are dependent on the hardness of the water, so the precise value of the acute and chronic NAWQC that applies to a sample depends on the

hardness of that sample. The equations and parameters used to calculate the acute and chronic NAWQC values for these metals are presented in Table C-2.

References:

Canadian Council of Ministers of the Environment (CCME). 1991. *Appendix IX - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life. April 1991. In: Canadian Water Quality Guidelines, CCME, 1987. Prepared by the Task Force on Water Quality Guidelines. [Updated and reprinted with minor revisions and editorial changes in Canadian Environmental Quality Guidelines, Chapter 4, CCME, 1999, Winnipeg.]*

http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/water_protocol-aquatic_life.htm

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US Environmental Protection Agency (USEPA). 2002a. *National Recommended Water Quality Criteria: 2002.* United States Environmental Protection Agency, Office of Water, Office of Science and Technology. November 2002. EPA-822-R-02-047.

US Environmental Protection Agency (USEPA). 2002b. *Region 4 Ecological Risk Assessment Bulletins - Supplement to RAGS.* Downloaded on July 15, 2002 from website: <http://www.epa.gov/region04/waste/ots/ecolbul.htm>

C-3 Sediment Benchmarks for Benthic Macroinvertebrates

Toxicity values for the protection benthic macroinvertebrates from contaminants in freshwater sediment are available from several sources. Each of these sources is described briefly below.

Consensus-Based Sediment Quality Guidelines

MacDonald et al. (2000) issued consensus-based sediment quality guidelines (SQGs) for 28 chemicals of concern, in an effort to focus on agreement among the various sediment quality guidelines. For each chemical of concern, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified based on available sediment toxicity literature. The consensus-based TECs were calculated by determining the geometric mean of all threshold effect values from the literature. The consensus-based PECs were calculated by determining the geometric mean of all probable effect values from the literature. A summary of the types of sediment effect concentrations included in the TEC and PEC calculations is provided in MacDonald et al. (2000).

The predictive reliability of these values was also evaluated. The predictive ability analyses were focused on the ability of each SQG when applied alone to classify samples as either toxic or non-toxic. Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the PEC. Individual TECs were considered reliable if more than 75% of the sediment samples were correctly predicted to be non-toxic. Similarly, the individual PEC was considered reliable if greater than 75% of the sediment samples were correctly predicted to be toxic. The SQGs were considered to be reliable only if a minimum of 20 samples were included in the predictive ability evaluation (MacDonald et al. 2000).

Because field collected sediments contain a mixture of chemicals, a second analysis was completed to investigate whether the toxicity of sediment could be predicted based on the average of the PEC ratios for the sediment, using only the PEC values that were found to be reliable. It was found that 92% of sediment samples with a mean PEC quotient > 1.0 were toxic to one or more species of aquatic organisms. The mean PEC quotient was found to be highly correlated with incidence of toxicity ($R^2 = 0.98$) (MacDonald et al. 2000).

ARCS Sediment Effect Concentrations

As part of the Assessment and Remediation of Contaminated Sediment (ARCS) Project, Ingersoll et al. (1996) compiled freshwater sediment toxicity data from nine different sites in the United States and identified a series of sediment effect concentrations (SECs) for a series of metals in sediment. The SECs are defined as the concentrations of individual contaminants in sediment below which toxicity is rarely observed and above which toxicity is frequently observed. The database was compiled to classify toxicity data for Great Lakes sediment samples and is segregated into "effect" data and "no effect" data. Ingersoll et al. (1996) derived five different SECs; effect range low (ERL),

effect range median (ERM), threshold effect level (TEL), probable effect level (PEL) and no effect concentration (NEC). The derivation of each of these SECs is presented below:

- effect range low (ERL) = 10th percentile of adverse effect data
- effect range median (ERM) = 50th percentile (median) of adverse effect data
- no effect range median (NERM) = 50th percentile (median) of no effect data
- no effect range high (NERH) = 85th percentile of no effect data
- threshold effect level (TEL) = geometric mean of ERL and NERM
- probable effect level (PEL) = geometric mean of ERM and NERH
- no effect concentration (NEC) = maximum of no effect data

The ERL is defined as the concentration below which adverse effects are unlikely to occur. The ERM is defined as the concentration of a chemical above which effects are frequently or always observed or predicted among most species. The NEC is the maximum concentration of a chemical in sediment that does not significantly adversely affect the particular response when compared to the control.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 Ecological Screening Levels (ESLs) for sediment were developed based on available federal freshwater sediment criteria and state-promulgated sediment quality guidelines (USEPA 1999). If no freshwater guidelines were available, marine criteria were used. For those chemicals for which no guidelines were available, an interim ESL was developed using the equilibrium partitioning approach. These interim guidelines were developed for both nonpolar and polar organic constituents. The equilibrium partitioning method is generally only applied to nonpolar organics, however, it was assumed to be a satisfactory method for organics for use on a screening level approach (USEPA 1999). The ESL was derived from the lowest federal, state or interim water quality guideline and assumes a total organic carbon content of 1%.

NOAA Sediment Effect Concentrations

The National Oceanic and Atmospheric Administration (NOAA) compiled sediment data from studies performed in both freshwater and saltwater (originally presented in NOS OMA Technical Memo 52, Long and Morgan 1990). The NOAA ERL and ERM were developed using the same procedures as outlined for the ARCS Project (Ingersoll et al. 1996). The NOAA ERL is defined as the concentration of a chemical in sediment below which adverse effects are rarely observed or predicted among sensitive species. The NOAA ERM is representative of concentrations above which effects frequently occur. The original data set used by Long and Morgan (1990) has since been supplemented with additional saltwater data, therefore these additional marine reports are not applicable (ie: Long et al. 1995).

USEPA Region 4 Screening Levels

The USEPA Region 4 Screening Levels are derived from three different sediment effects data sets including NOAA freshwater and marine data from Long and Morgan (1990), additional NOAA marine data from Long et al. (1995), and Florida State Department of Environmental Protection marine data from MacDonald et al. (1996). The sediment effect level is based on the reported ERL from each study. In instances when the USEPA Contract Laboratory Program (CLP) practical quantitation limit (PQL) is above the effect level, the screening value is equal to the CLP PQL (USEPA 2002).

CCME Sediment Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) derived sediment quality guidelines to support protection and management strategies for freshwater, estuarine, and marine ecosystems (CCME 1995). Guideline derivation protocols are detailed in CCME (1995) and are similar to the procedures described previously for the ARCS Project (Ingersoll et al. 1996). Separate guidelines were derived for freshwater and marine sediments (CCME 2001). The freshwater interim sediment quality guideline (ISQG) was equal to the TEL and is representative of the concentration below which adverse effects are not anticipated for aquatic life associated with bed sediments (CCME 1995). A PEL was also calculated to establish concentrations above which adverse effects are likely to occur.

Ontario Sediment Effect Levels

Persaud et al. (1993) derived sediment effect levels for the protection of aquatic organisms in Ontario, Canada. Three types of sediment quality guidelines were developed; a No Effect Level (no toxic effects), a Low Effect Level (tolerable by benthic species), and a Severe Effect Level (detrimental to most benthic species). A summary and review of the available approaches to sediment guideline development and the protocol for the derivation of the Ontario values is described in detail in Persaud et al. (1993). Briefly, the No Effect Level is obtained through a chemical equilibrium approach using water quality standards. Because the equilibrium partitioning approach is only predictive for nonpolar organics, a No Effect Level is not derived for metals and polar organics. The Low Effect Level and Severe Effect Level are based on the 5th and 95th percentiles of all effects data for bulk sediment analysis, respectively. For non-polar organics these concentrations were normalized for total organic carbon.

Of these sources, the following are excluded from use in this risk assessment due to inadequate documentation of derivation methodology, use of site-specific assumptions, use of marine or estuarine sediments, use of inappropriate receptors, or errors in benchmark derivation.

- USEPA Region 5 Screening Levels
- USEPA Region 4 Screening Levels
- CCME Sediment Quality Guidelines (ISQG/PEL)
- Ontario Sediment Effect Levels (Low/Severe)

Of the remaining sources, a benchmark selection hierarchy is established as follows and a summary of all selected sediment toxicity benchmarks is shown in Table C-3.

- Consensus based TEC (MacDonald et al., 2000)
- ARCs TEL (Ingersoll et al., 1996)
- NOAA ERL (Long and Morgan, 1990)

References:

Canadian Council of Ministers of the Environment (CCME). 1995. *Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. CCME EPC-98E. Prepared by Environment Canada, Guidelines Division, Technical Secretariat of the CCME Task Group on Water Quality Guidelines, Ottawa. [Reprinted in Canadian Environmental Quality Guidelines, Chapter 6, CCME, 1999, Winnipeg.]

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<http://www.epa.gov/region04/waste/ots/ecolbul.htm>

Terrestrial Receptors (Plants & Soil Invertebrates)

C-4 Soil Benchmarks for Plants and Soil Invertebrates

Toxicity values for the protection of plants and soil invertebrates from contaminants in surficial soils are available from several sources. Each of these sources is described briefly below.

Ecological Soil Screening Levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern (COPCs) in soils requiring further evaluation in a baseline ecological risk assessment (ERA). Eco-SSLs are derived separately for four groups of ecological receptors, plants, soil invertebrates, birds and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. The lower of the values for plants and soil invertebrates is used preferentially as the Eco-SSL.

The Eco-SSL derivation process represents a three year collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry and academic participants led by the USEPA, Office of Emergency and Remedial Response (OERR) (USEPA, 2002b). The USEPA will issue the final guidance for Eco-SSLs and interim final Eco-SSL values for several contaminants in 2003.

Oak Ridge National Laboratory Plants/Soil Organisms/Microbes

Oak Ridge National Laboratory (ORNL) reviewed data on the toxicity of contaminants in soil on a wide range of plants, soil organisms, and microbes, and determined the lowest observed effect concentration (LOEC) (Efroymson et al. 1997a,b). The LOEC is defined as the lowest applied concentration of the chemical causing a greater than 20% reduction in the measured response. In some cases, the LOEC is the lowest concentration tested or the only concentration reported (EC50 or ED50 data). The LOECs for a series of different plants and soil organisms are rank ordered and a value selected that approximated the 10th percentile. When a benchmark is based on a lethality endpoint, the benchmark value is divided by 5 to approximate an effects concentration for growth and reproduction. The factor is selected based on the author's judgement (Efroymson et al. 1997a,b). The benchmark values are then rounded to one significant figure.

Dutch Target and Intervention Values

The Dutch Target and Intervention Values are derived from available data on ecotoxicological effects of contaminants in soil to terrestrial species and soil microbial processes (Swartjes 1999). The Target Values for soil are related to negligible risk for soil ecosystems (95% protection). The Intervention Values are defined as the hazardous concentration for 50% of the soil ecosystem population and are not protective of sensitive species. The Dutch benchmarks are developed by reviewing available literature to determine the lowest no observed effect concentration (NOEC). When there is a LOEC but no NOEC, the NOEC is estimated from the LOEC according to the effect level observed at the LOEC, as follows:

LOEC Effect Range	NOEC
10% - 20%	LOEC / 2
20% - 50%	LOEC / 3
50% - 80%	LOEC / 10

The ecotoxicological data are selected according to the criteria established in Crommentuijn et al. (1994) and are normalized for soil characteristics such as organic matter and clay content. If not enough data is available for terrestrial species and microbial processes, aquatic data (adjusted by an uncertainty factor of 10) are used to derive the benchmark values (Swartjes 1999).

CCME Soil Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) established effects-based environmental soil quality guidelines (SQG_E) designed to be clean-up goals to protect ecological receptors from direct contact and ingestion exposures to soil-based contaminants. From the available soil toxicity literature, CCME compiled an adverse effect data set and a no effect data set. Several SQG_E s are calculated based on land use types (agricultural-A, residential/parkland-R/P, commercial/industrial-C/I). Based on the amount of toxicity data available, different derivation methods are used to calculate the land use SQG_E . Each of these methods are detailed in CCME (1999) and described briefly below.

Weight-of Evidence Method

A, R/P Land Uses = threshold effects concentration (TEC), 25th percentile of effect and no effect data sets divided by an uncertainty factor

C/I Land Use = effects concentration low (ECL), 25th percentile of effect data set

Lowest-Observed-Effect Concentration (LOEC) Method

A, R/P Land Uses = lowest available LOEC divided by an uncertainty factor

C/I Land Use = geometric mean of available LOEC data

Median Effects Method

A, R/P Land Uses = lowest available EC50 or LC50 divided by an uncertainty factor

C/I Land Use = no guideline calculated

In addition to calculating an SQG_E , CCME also derived SQGs for human health (SQG_{HH}). The final soil guideline is the minimum of the SQG_E and the SQG_{HH} .

USEPA Region 4 Ecological Screening Levels

The USEPA Region 4 compiled soil toxicity screening benchmarks from several sources including ORNL (Efroymson et al. 1997a,b), CCME (CCME 1997), and Dutch values (Crommentuijn et al. 1994). From these sources, screening levels are selected based on

contaminant levels associated with ecological effects (USEPA 2002b). These screening values do not take into account area or regional background levels.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 reviewed and evaluated soil quality criteria from international, federal, and state sources (USEPA 1999). A default soil ecological screening level (ESL) is selected based on the lowest receptor-specific ESL for terrestrial (plant/soil organisms) and wildlife receptors found during a review of existing toxicological information. The ESL is derived from the concentration which resulted in no observed adverse effects (NOAEL) for chronic exposure of the target species. When a chronic value is not available, the most relevant toxicological result is adjusted by division with uncertainty factors as appropriate to approximate the chronic NOAEL for the selected receptor (USEPA 1999).

Because the CCME final SQGs do not make a distinction between ecological and human health benchmarks, they are not included as a benchmark source. Because the USEPA Region 5 ESLs do not make a distinction between soil benchmarks derived from plant/soil organism data and wildlife data, these values are excluded from consideration as a benchmark source. The Region 4 benchmarks are also excluded because they are based on primary sources that had been previously reviewed. For the remaining sources, selection of the surficial soil toxicity benchmarks for terrestrial receptors is based on the following hierarchy:

- Minimum of the Eco-SSLs for plants and soil invertebrates
- Minimum of the ORNL plant, soil organism, microbe benchmarks

The soil benchmark values for all chemicals analyzed in surface soils are shown in Table C-4.

References:

Canadian Council of Ministers of the Environment (CCME). 1997. *Recommended Canadian Soil Quality Guidelines*. CCME, Winnipeg.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Summary of the Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. In: *Canadian Environmental Quality Guidelines, Chapter 7*, CCME, 1999, Winnipeg.

Crommentuijn, GH, EJ Van der Plassche and JH Canton. 1994. *Guidance Document on the Derivation of Ecotoxicological Criteria for Serious Soil Contamination in View of the Intervention Value for Soil Clean-up*. RIVM report 950011003. RIVM, Bilthoven, The Netherlands.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc. managing the Oak Ridge National Laboratory (ORNL). ORNL publication. ES/ER/TM-85/R3, November 1997.

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Wildlife Receptors (Birds & Mammals)

C-5 Risk-Based Concentrations for Birds and Mammals

Numerous studies have been conducted that provide information on toxicity associated with experimental exposures for a variety of birds and mammals. Two different sources were identified which provided wildlife RBCs that were derived. Each of these sources is described briefly below.

Ecological Soil Screening Levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern (COPCs) in soils requiring further evaluation in a baseline ecological risk assessment (ERA). Eco-SSLs are derived separately for four groups of ecological receptors, plants, soil invertebrates, birds and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. The lower of the values for plants and soil invertebrates is used preferentially as the Eco-SSL.

The Eco-SSL derivation process represents a three year collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry and academic participants led by the USEPA, Office of Emergency and Remedial Response (OERR) (USEPA, 2002b). The USEPA will issue the final guidance for Eco-SSLs and interim final Eco-SSL values for several contaminants in 2003.

For the purposes of performing an initial screen for wildlife, the Eco-SSL RBCs for birds and mammals were used preferentially. If an Eco-SSL RBC was not available for a specific contaminant, then the RBC derived for either the American robin for birds, or the white-footed mouse for mammals under the Denver Federal Center Risk Assessment Work Plan Part B was used.

References:

Denver Federal Center Risk Assessment Work Plan Part B, June 2004.

US Environmental Protection Agency (USEPA). 2003. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER Directive 92857-55. Office of Solid Waste and Emergency Response. November 2003.

ATTACHMENT C

TOXICITY BENCHMARKS SURFACE WATER, SEDIMENT, & SOIL

Table C-1. Surface Water Toxicity Benchmarks for Aquatic Receptors

Table C-2. Ambient Water Quality Criteria for Detected Metals that are Hardness-Dependent and Freshwater Conversion Factors for the Calculation of Dissolved Fraction

Table C-3. Sediment Toxicity Benchmarks for Benthic Macroinvertebrates

Table C-4. Soil Toxicity Benchmarks for Plants and Soil Invertebrates

Table C-5. Risk-Based Concentrations for Birds and Mammals

Table C-1. Surface Water Toxicity Benchmarks for Aquatic Receptors

Analyte Type	Analyte	ACUTE				CHRONIC					
		NAWQC - Acute (ug/L) ¹	GLWQI Tier II SAV (ug/L) ²	USEPA R4 - Acute (ug/L) ²	Surface Water Acute Benchmark (ug/L)	NAWQC - Chronic (ug/L) ¹	GLWQI Tier II SCV (ug/L) ²	USEPA R4 - Chronic (ug/L) ²	Other (ug/L) ²		Surface Water Chronic Benchmark (ug/L)
Metals	Barium	50000 ⁶	110	--	50000	5000 ³	--	--	--		5000
	Copper	38 ^{4, 7}	--	18	38	23 ^{4, 7}	--	11.8	--		23
	Iron	--	--	--	no benchmark	1000	--	1000	300	CCME WQG	1000
	Manganese	--	2300	--	2300	--	120	--	--		120
	Vanadium	--	280	--	280	--	20	--	--		20
Anions	Calcium	--	--	--	no benchmark	--	--	--	--		no benchmark
	Magnesium	--	--	--	no benchmark	--	--	--	82,000	LCV Daphnids	82,000
	Potassium	--	--	--	no benchmark	--	--	--	53,000	LCV Daphnids	53,000
	Sodium	--	--	--	no benchmark	--	--	--	680,000	LCV Daphnids	680,000
Petroleum Hydrocarbons	Benzene	--	2300	530	2300	--	130	53	--		130
	C5 to C8 Aliphatics	--	--	--	no benchmark	--	--	--	--		no benchmark
	Total Purgeable Hydrocarbons	--	--	--	no benchmark	--	--	--	--		no benchmark
	Total Extractable Hydrocarbons	--	--	--	no benchmark	--	--	--	--		no benchmark
Nitrogen Compounds	Nitrogen, Nitrite as N	--	--	--	no benchmark	--	--	--	60	CCME WQG	60
	Nitrogen, Nitrate as N	--	--	--	no benchmark	--	--	--	--		no benchmark
RAD	Gross Alpha	--	--	--	no benchmark	--	--	--	--		no benchmark
Anions	Chloride	860000	--	860000	860000	230000	--	230000	--		230000
	Fluoride	--	--	--	no benchmark	--	--	--	--		no benchmark
	Sulfate	--	--	--	no benchmark	--	--	--	--		no benchmark
	Phosphorus, Orthophosphate as P	--	--	--	no benchmark	--	--	--	--		no benchmark
Water Quality	TDS	6000000 ⁵	--	--	6000000	--	--	--	300000	5; LOEC Daphnids	300000
	TSS	--	--	--	no benchmark	--	--	--	--		no benchmark

¹USEPA, 2002. National Recommended Water Quality Criteria: 2002. November 2002. EPA 822-R-02-047.

²Suter & Tsao, 1996.

³Only acute NAWQC available; chronic NAWQC is equal to acute / 10.

⁴Metal toxicity is hardness-dependent; values shown are calculated based on a hardness of 299 mg/L.

⁵National Irrigation Water Quality Program (1998)

⁶Based on USEPA Gold Book value.

⁷NAWQC expressed in terms of the dissolved fraction.

NAWQC = National Ambient Water Quality Criteria

GLWQI = Great Lakes Water Quality Initiative

SAV/SCV = Secondary Acute/Chronic Value

CCME = Canadian Council of Ministers of the Environment

WQG = Water Quality Guidelines

LCV = Lowest Chronic Value

**Table C-2. Ambient Water Quality Criteria for Detected Metals that are Hardness-Dependent
and Freshwater Conversion Factors for the Calculation of Dissolved Fraction**

Analyte	Hardness-Dependent Parameters				AWQC based on Total Recoverable (ug/L)		Total/Dissolved Conversion Factors				AWQC based on Dissolved (ug/L)	
	where: $AWQC_{tot} = \exp(a * \ln(H) + b)$						where: $AWQC_{diss} = AWQC_{tot} * [m-n*(\ln(H))]$					
	Acute		Chronic				Acute		Chronic			
	a	b	a	b	Acute	Chronic	m	n	m	n	Acute	Chronic
Copper	0.9422	-1.7	0.8545	-1.7020	39	24	0.9600	0.0000	0.9600	0.0000	38	23

AWQCs are presented based on the hardness of 299 mg/L.

Sources:

USEPA, 2002. National Recommended Water Quality Criteria: 2002. US Environmental Protection Agency, Office of Water, Office of Science and Technology. November 2002. EPA 822-R-02-047.

Table C-3. Bulk Sediment Toxicity Benchmarks for Benthic Macroinvertebrates

Analyte Type	Analyte	Threshold Effect Concentrations (TEC) ¹					Probable Effect Concentrations (PEC) ²		
		Consensus-Based TEC (mg/kg) ^a	ARCS TEL (mg/kg) ^b	EqP Value (mg/kg) ^c	ESGs for PAHs (mg/kg) ^d	Sediment Screening Benchmark (mg/kg)	Consensus-Based PEC (mg/kg) ^a	ARCS PEL (mg/kg) ^b	Sediment Screening Benchmark (mg/kg)
Metals	Aluminum	--	25,519	--	--	25,519	--	59,572	59,572
	Arsenic	10	11	--	--	10	33	48	33
	Barium	--	--	--	--	no benchmark	--	--	no benchmark
	Chromium	43	36	--	--	43	111	120	111
	Cobalt	--	--	--	--	no benchmark	--	--	no benchmark
	Copper	32	28	--	--	32	149	100	149
	Iron	--	188,400	--	--	188,400	--	247,600	247,600
	Lead	36	37	--	--	36	128	82	128
	Manganese	--	631	--	--	631	--	1184	1,184
	Nickel	23	20	--	--	23	49	33	49
	Selenium	--	--	--	--	no benchmark	--	--	no benchmark
	Thallium	--	--	--	--	no benchmark	--	--	no benchmark
	Vanadium	--	--	--	--	no benchmark	--	--	no benchmark
	Zinc	121	98	--	--	121	459	540	459
	Mercury	0.18	--	--	--	0.180	1.06	--	1.06
VOC	Methyl acetate	--	--	--	--	no benchmark	--	--	no benchmark
PAH	Pyrene	0.195	0.57	--	6.97	0.195	1.52	--	1.52
Petroleum Hydrocarbons	C11 to C22 Aromatics	--	--	--	--	no benchmark	--	--	no benchmark
	C19 to C36 Aliphatics	--	--	--	--	no benchmark	--	--	no benchmark
	C9 to C18 Aliphatics	--	--	--	--	no benchmark	--	--	no benchmark
	Total Extractable Hydrocarbons	--	--	--	--	no benchmark	--	--	no benchmark
	C9 to C10 Aromatics	--	--	--	--	no benchmark	--	--	no benchmark
	C9 to C12 Aliphatics	--	--	--	--	no benchmark	--	--	no benchmark
	Total Purgeable Hydrocarbons	--	--	--	--	no benchmark	--	--	no benchmark

Notes:

- 1 The TEC encompasses several types of sediment quality guidelines including the Lowest Effect Level (LEL), the Threshold Effect Level (TEL), the Effect Range Low (ERL), the TEL for *Hyalella azteca* in 28 day tests (TEL-HA28), and the Minimum Effect Thres
- 2 The PEC encompasses several types of sediment quality guidelines including the Severe Effect Level (SEL), the Probable Effect Level (TEL), the Effect Range Median (ERM), the PEL for *Hyalella azteca* in 28 day tests (PEL-HA28), and the Toxic Effect Thres

Sources Hierarchy:

- a MacDonald et al. (2000); consensus-based threshold effect concentration (TEC) and probable effect concentration (PEC).
- b Ingersoll, et al. (1996); Threshold Effect Level (TEL) and Probable Effect Level (PEL) for total extraction of sediment (BT) samples from *Hyalella azteca* 28-day (HA28) tests.
- c Derived based on the equilibrium partitioning (EqP) approach as described in Region 5 ESL Guidance (USEPA, 1999) normalized to 1% TOC.
- d USEPA (2000); Equilibrium-partitioning sediment guidelines (ESGs) $C_{OC,PAH,FCV1}$ normalized to 1% TOC.

Table C-4. Soil Toxicity Benchmarks for Plants & Soil Invertebrates

Analyte Type	Analytes	EcoSSL Plants (mg/kg dw)	ORNL Plants (mg/kg dw)	EcoSSL Invertebrates (mg/kg dw)	ORNL Invertebrates (mg/kg dw)	Dutch Target (mg/kg dw) ^c	Lowest Screening Level Benchmark (mg/kg)
Metals	Aluminum	(a)	50	(a)	--	--	(a)
	Antimony	--	5	78	--	3	5
	Arsenic	18	10	--	60	29	18
	Barium	--	500	330	--	160	330
	Chromium	--	1	--	0.40	100	0.4
	Cobalt	13	20	--	--	9	13
	Copper	70	100	80	50	36	70
	Iron	(b)	--	(b)	--	--	no benchmark
	Lead	120	50	1700	500	85	120
	Manganese	220	500	450	--	--	220
	Mercury	--	0.3	--	0.1	0.3	0.3
	Nickel	38	30	280	200	35	38
	Thallium	--	1	--	--	1	1
	Vanadium	--	2	--	--	42	2
	Zinc	160	50	120	100	140	120
Pesticide	Pentachlorophenol	5	3	31	6	--	5
VOC	Methyl acetate	--	--	--	--	--	no benchmark
PAHs	Benzo(a)anthracene	--	--	18	--	--	18
	Benzo(a)pyrene	--	--	18	--	--	18
	Benzo(b)fluoranthene	--	--	18	--	--	18
	Benzo(g,h,i)perylene	--	--	18	--	--	18
	Benzo(k)fluoranthene	--	--	18	--	--	18
	Chrysene	--	--	18	--	--	18
	Indeno(1,2,3-cd)pyrene	--	--	18	--	--	18
	Pyrene	--	--	18	--	--	18
	Total High Molecular Weight PAHs	--	--	--	--	--	18
Petroleum Hydrocarbons	C11 to C22 Aromatics	--	--	--	--	--	no benchmark
	C19 to C36 Aliphatics	--	--	--	--	--	no benchmark
	C9 to C18 Aliphatics	--	--	--	--	--	no benchmark
	C5 to C8 Aliphatics	--	--	--	--	--	no benchmark
	C9 to C10 Aromatics	--	200	--	--	0.01	200
	Toluene	--	--	--	--	--	no benchmark
	Total Purgeable Hydrocarbons	--	--	--	--	--	no benchmark
	Total Extractable Hydrocarbons	--	--	--	--	--	no benchmark

^aThe Eco-SSL for aluminum consists of a narrative statement. Aluminum is considered to be a contaminant of potential concern under conditions where soil pH is less than 5.5.

^bA numeric Eco-SSL for iron was not derived. The potential toxicity of iron in soils is dependant on soil pH and Eh.

^cBased on the Dutch Target Value presented in Swartjes (1999).

Table C-5. RBCs for Birds and Mammals

Category	Analyte	Risk Based Concentrations (mg/kg)			
		Birds		Mammals	
		RBC	Source	RBC	Source
Metals	Aluminum	pH-dependent	1 ^a	pH-dependent	1 ^a
	Antimony	no benchmark		0.27	1
	Arsenic	43	1	46	1
	Barium	865	2	2,000	1
	Chromium	26	1 ^b	34	1 ^b
	Cobalt	120	1	230	1
	Copper	28	1	49	1
	Iron	no benchmark	1 ^c	no benchmark	1 ^c
	Lead	11	1	56	1
	Manganese	4,300	1	4,000	1
	Mercury	0.161	2	1.2	2
	Nickel	210	1	130	1
	Thallium	0.29	2	0.10	2
	Vanadium	7.8	1	280	1
	Zinc	46	1	79	1
Pesticide	Pentachlorophenol	2.1	1	2.8	1
VOC	Methyl acetate	no benchmark		no benchmark	
PAHs	Benzo(a)anthracene	no benchmark		1.10	1
	Benzo(g,h,i)perylene	no benchmark		1.10	1
	Benzo(a)pyrene	no benchmark		1.10	1
	Benzo(b)fluoranthene	no benchmark		1.10	1
	Benzo(k)fluoranthene	no benchmark		1.10	1
	Chrysene	no benchmark		1.10	1
	Indeno(1,2,3-cd)pyrene	no benchmark		1.10	1
	Pyrene	no benchmark		1.10	1
Petroleum Hydrocarbons	C11 to C22 Aromatics	no benchmark		no benchmark	
	C19 to C36 Aliphatics	no benchmark		no benchmark	
	C9 to C18 Aliphatics	no benchmark		no benchmark	
	C5 to C8 Aliphatics	no benchmark		no benchmark	
	C9 to C10 Aromatics	no benchmark		no benchmark	
	Toluene	no benchmark		0.74	2
	Total Extractable Hydrocarbons	no benchmark		no benchmark	
	Total Purgeable Hydrocarbons	no benchmark		no benchmark	

^a Aluminum is expected to be a contaminant of potential concern only when pH is below 5.5.

^b Based on Cr³⁺ (the lower of the Cr³⁺ and Cr⁶⁺ values).

^c Iron is an essential nutrient for wildlife, and is not expected to be a primary contaminant of concern at most sites

Source:

1 -- USEPA Ecological Soil Screening Level (Eco-SSL) Documents

2 -- Based on the American Robin and the White-footed Mouse (Denver Federal Center Risk Assessment Work Plan Part B, June 2004.)

2.0 ANALYTICAL METHODS

Analytical methods that are available for detecting and measuring asbestos in environmental media are summarized in Table 1. The methods are described in greater detail in the following subsections.

Light Microscopy

Phase Contrast Microscopy (PCM)

Phase contrast microscopy (PCM) is an analytical method used mainly for measuring asbestos in air. A known volume of air is drawn through a filter and asbestos fibers in the air are deposited on the filter. A portion of the filter is then prepared for examination under a phase contrast microscope. In this type of microscopy, light that passes through a particle such as an asbestos fiber becomes delayed ("out of phase") compared to light passing next to the particle. This difference in phase between light passing through a particle and near a particle is used to increase the contrast (visibility) of the particle, which allows visualization of structures that otherwise would be very difficult to observe under ordinary light microscopy. The limit of resolution of PCM is about 0.25 μm , so particles thinner than this are generally not observable.

A key limitation of PCM is that particle discrimination is based only on size and shape. Because of this, it is not possible to classify asbestos particles by mineral type, or even to distinguish between asbestos and non-asbestos particles. Consequently, structures that are counted by PCM may include a variety of naturally occurring non-asbestos minerals that may occur in the form of long thin structures, as well as non-mineral particles such as animal hair and synthetic fibers. This tends to overestimate the true concentration of asbestos, especially in non-industrial settings. Conversely, PCM may also tend to underestimate the true asbestos content of a sample since particles that are thinner than 0.25 μm are generally too thin to be observed.

One common method for the application of PCM to the analysis of asbestos in air is NIOSH Method 7400 (NIOSH 1994a). This method provides a full description of how samples should be collected, prepared and examined. Under NIOSH 7400, a structure is defined as any particle more than 5 μm in length with an aspect ratio $\geq 3:1$. In general, complex particles (bundles, clusters) are counted as single particles, unless the individual components can be clearly identified (by observing both ends of each individual fiber). Results are generally reported in units of PCM structures per cubic centimeter (f/cc) of air.

Polarized Light Microscopy (PLM)

Polarized light microscopy (PLM) is an analytical method used mainly for examining asbestos particles in soil and sediment material. In this type of microscopy, light is transmitted through

the sample and then filtered with a polarizing lens in order to visualize its components. This method allows for qualitative identification of asbestos particles and semi-quantitative determination of asbestos content in bulk samples. The limit of detection for this method is < 1% asbestos. Results are generally reported as area fraction or mass fraction.

There are three common methods for the application of PLM to the analysis of asbestos in soil/sediment, PLM visual area estimation (PLM-VE), PLM gravimetric (PLM-GRAV), and PLM point counting (PLM-PC).

PLM-VE is a semi-quantitative method for identifying and quantifying asbestos fibers in soil. This method requires the microscopist to estimate the area fraction (AF%) of the total material present in a field of view that consists of asbestos material. This method is based on NIOSH Method 9002 (NIOSH 1994b), EPA Method 600/R-93/116 (USEPA 1993), and CARB Method 435 (CARB 1991), with project-specific modifications intended specifically for use at the Libby Superfund Site as detailed in SRC-LIBBY-03. At Libby, soil samples are ground prior to analysis, results for Libby amphibole (LA) are reported as mass fraction based on site-specific calibration standards, and LA concentrations less than 1% are stratified into 3 classification bins – non-detect, trace (<0.2%), and <1%.

PLM-GRAV is a semi-quantitative method for identifying and quantifying asbestos fibers in coarse soil fractions (particles that are retained on a 1/4" sieve). This method requires the microscopist to first identify and segregate suspected asbestos particles using stereomicroscopy. The tentatively identified asbestos particles will be examined by PLM (as described above) and the total weight of each type of positively identified asbestos will be determined gravimetrically. This method is based on NIOSH Method 9002 (NIOSH 1994b) and SRC-LIBBY-01. At Libby, particles smaller than 2-3 mm are not large enough to weigh so the results are reported semi-quantitatively into 2 classification bins – non-detect and trace.

PLM-PC is a quantitative method that involves counting the total number of particles (asbestos vs. non-asbestos) (generally 400 or 1,000) lying on superimposed points in the microscope field created by an ocular reticule (point array) or cross-hair. In order for a particle to be counted as asbestos, the aspect ratio must be 3:1. This method is based on EPA/600/R-93/116 (USEPA 1993) and CARB Method 435 (CARB 1991), with project-specific modifications intended specifically for use at the Libby Superfund Site as detailed in SRC-LIBBY-03. At Libby, point-count estimates of area fraction for LA particles will be converted into estimates of mass fraction using a standard curve prepared using a series of site-specific reference materials containing 0%, 0.2%, 0.5%, 1%, or 2% LA.

Electron Microscopy

Transmission Electron Microscopy (TEM)

Transmission electron microscopy (TEM) is used mainly to evaluate samples of water, air, or dust that have been collected on a filter. This method utilizes a high energy electron beam rather than a beam of light to irradiate the sample. TEM can be used to analyze asbestos in all types of environmental samples (air, water, soil, sediment) and in biological samples (tissue). Instead of glass lenses focusing the light wavelengths, electromagnetic lenses are used to focus the electrons on the sample. This allows operation at higher magnification (typically about 15,000x) and visualization of structures much smaller than can be seen under light microscopy. In addition, most TEM instruments are fitted with one or both of two supplemental accessories that allow a more detailed characterization of a particle than is possible under light microscopy:

EDS (Energy dispersive spectroscopy) provides data on the elemental composition of each particle being examined. This makes it possible to distinguish organic particles from mineral particles, and also allows for distinguishing between different types of minerals.

SAED (selected area electron diffraction) provides the x-ray diffraction pattern for each particle. This information is helpful in distinguishing organic from mineral particles, and in classifying the type of asbestos (e.g. chrysotile vs. amphibole).

A variety of different methods have been developed for use of TEM to analyze asbestos, including ISO 10312 (ISO 1995), AHERA (USEPA 1987), NIOSH 7402 (NIOSH 1994c) and EPA 100.2 (EPA 1994). These methods differ from each other mainly in the counting rules that specify the minimum length, width and aspect ratio requirements for counting a particle, and in the strategy for dealing with complex structures (bundles, clusters, matrix particles). At Libby, in order for a particle to be counted as asbestos, the length must be 0.5 μm and the aspect ratio must be 3:1. Results are generally reported in units of structures per cubic centimeter of air (s/cc) for air samples, million fibers per liter (MFL) for water samples, structures per gram soil/sediment (s/g) for solid samples, and structures per gram of tissue (s/g) for biological samples.

When a sample is analyzed by TEM, individual asbestos structures are observed, and their size, shape, and mineral class are recorded. At Libby, the mineral classes are categorized as:

- LA Libby-class amphibole. Structures having an amphibole SAED pattern and an elemental composition similar to the range of fiber types observed in ores from the Libby mine (USGS,2001). This is a sodic tremolitic solid solution series of minerals including actinolite, tremolite, winchite, and richterite, with lower amounts of magnesio-arfvedsonite and edenite/ferro-edenite.

- OA Other amphibole-type asbestos fibers. Structures having an amphibole SAED pattern and an elemental composition that is not similar to fibers types from the Libby mine. Examples include crocidolite, amosite, and anthophyllite. There is presently no evidence that these fibers are associated with the Libby mine.
- C Chrysotile fibers. Structures having a serpentine SAED pattern and an elemental composition characteristic of chrysotile. There is presently no evidence that these fibers are associated with the Libby mine.
- NAM Non-asbestos material. These may include non-asbestos mineral fibers such as gypsum, glass, or clay, and may also include various types of organic and synthetic fibers derived from carpets, hair, etc.

Scanning Electron Microscopy (SEM)

Scanning electron microscopy (SEM) may be used to evaluate filtered samples of water, air or dust, and may also be used to evaluate asbestos fibers found in solid samples and biological samples. Like TEM, scanning electron microscopy (SEM) uses high energy electrons to irradiate the filter, but the image is generated from diffracted rather than transmitted electrons. Thus, an SEM image is more three-dimensional than a TEM image. Most SEM instruments are fitted with EDS but not SAED. Thus, it is normally possible to distinguish asbestos from non-asbestos particles and to classify asbestos particles by mineral type, but the determination is less definitive than by TEM. However, except in situations where fiber classification is difficult, differences between fiber counting results obtained by SEM and TEM will generally be minor (ISO 2002).

3.0 FATE AND TRANSPORT OF ASBESTOS IN THE ENVIRONMENT

Releases to the Environment

Asbestos occurs naturally in the environment and may be released to water and air from erosion and the weathering of natural deposits of asbestos-bearing rocks. However, asbestos is more likely to be released to the environment when these natural deposits are disturbed during processes such as mining operations. Asbestos is also released to the environment from the crushing, screening, and milling of ore, the processing of asbestos products, the use of asbestos-containing materials, and the transport and disposal of asbestos-containing wastes (ATSDR, 2001).

Transport and Deposition

Once asbestos fibers enter the environment from either a natural or artificial source, they tend to settle out of the air or water and deposit in soil and sediment (USEPA, 1977; USEPA, 1979). Asbestos fibers can be re-suspended into the air or water following soil and sediment disturbances. The rate at which asbestos particles settle out of the air or water depends on their size, and interaction with natural organic matter may increase their precipitation in aqueous environments (ATSDR, 2001; USEPA, 1979). Jaenicke (1979) reported that the residence time for a particle to remain airborne is shortest for the smallest (0.001 μm in diameter) and largest particles (100 μm in diameter), and greatest for particles ranging from 0.1-1 μm in diameter. Fibers in this size range could be transported long distances in air.

In water, asbestos fibers may also travel long distances from the point of origin, depending on the surface chemistry and detailed mineralogy of the fiber (USEPA, 1979). Tailings from taconite mining containing asbestos fibers dumped into Lake Superior were detected in the drinking water of Duluth, MN, about 75 miles away from the point source (USEPA, 1979).

In soils, asbestos will tend to be retained at or near the surface. Movement of asbestos fibers through soils occurs during runoff or erosion. Asbestos particles in soil are fairly immobile, and particles less than 2 μm in diameter will tend to move at the same rate as clays (about 1-10 cm per 3,000-40,000 years) (USEPA, 1977). Asbestos fibers deposited in soil may be re-suspended into the air by disturbing the contaminated soil (e.g. vehicular traffic and mining operations).

Transformation and Degradation in the Environment

Asbestos fibers are nonvolatile and insoluble; they are transported and distributed by air and water and tend to persist under typical environmental conditions (ATSDR, 2001). In general, asbestos is exceptionally resistant to thermal degradation and chemical attack. However, there are differences in the ability of different types of asbestos to persist in the environment. For instance, chrysotile asbestos is expected to degrade more readily than amphibole asbestos under certain environmental conditions (e.g. acidic environments) (ATSDR, 2001).

Air. Asbestos particles are not known to undergo any significant transformation or degradation in air (ATSDR, 2001).

Water. Asbestos fibers are relatively stable in water and are not prone to significant chemical or biological degradation. However, some asbestos fibers may undergo chemical alteration and adsorb additional organic agents. In general, asbestos does not volatilize from water surfaces. In water, at low pH, chrysotile asbestos may undergo some dissolution as magnesium hydroxide leaches from the outer brucite layer, but amphibole asbestos is expected to persist in aquatic environments virtually unchanged for long periods of time (ATSDR, 2001).

Soil. In general, asbestos fibers are not known to undergo significant transformation or degradation in soil (ATSDR, 1999). However, the World Health Organization (WHO, 1998) reports that chrysotile asbestos in surface soil will undergo chemical degradation producing profound changes in soil pH and releasing a variety of trace metals in to the environment (WHO, 1998).

4.0 ASBESTOS TOXICITY

A literature search was performed to identify studies that provide information on the effects of asbestos on ecological receptors. Attachment 1 provides a summary of the studies that were located. In general, toxicity data are very limited for most ecological receptors and absent for others. A summary of the information that is available is presented below.

Aquatic Invertebrates

To date, only three studies have been identified that provide data on the toxicity of asbestos in water to aquatic invertebrate species. In these studies the form of asbestos used in the exposures was either chrysotile or crocidolite and not LA. Adverse effects that have been observed in aquatic invertebrates exposed to asbestos in water under laboratory conditions include increased mortality and decreased growth and reproduction. Decreased siphoning activity, decreased growth and decreased reproduction (increased larval mortality) was observed in the adult asiatic clam (*Corbicula fluminea*) exposed to asbestos concentrations (chrysotile) as low as 10^4 fibers/L (Belanger et al., 1986). In larval *C. fluminea*, increased siphoning activity and decreased growth was observed at lower asbestos concentrations of 10^2 fibers/L (Belanger et al., 1986). The exposed larval *C. fluminea* accumulated in asbestos fibers in the gill and visceral tissue when exposed to 10^8 f/L and the fiber accumulations in gill tissue were associated with deteriorated gill tissue (Belanger et al., 1986). In brine shrimp, significant mortality was observed at exposures of 1.2×10^8 fibers/L of chrysotile asbestos but not crocidolite (Stewart and Schurr 1980).

Fish

To date, seven studies have been identified exposing five different fish species to asbestos in surface water. In all of these studies, the form of asbestos was chrysotile. Adverse effects that have been observed in fish exposed to asbestos in laboratory water include decreased growth, increased mortality, and altered behavior. Adverse effects observed in larval Japanese medaka (*Oryzias latipes*) exposed to asbestos (chrysotile) included decreased growth, increased mortality, and increased thickening of the epidermis at concentrations of 1×10^6 fibers/liter (L) and higher (Belanger et al., 1990). In Coho salmon (*Oncorhynchus kisutch*), significant adverse effects on behavior were observed at asbestos (chrysotile) exposures of $.5 \times 10^6$ fibers/L including adverse rheotactic position and balance. Fish were found laying on their sides in the bottom of the tank by day 13 and by day 20 nearly all fish were displaying this behavior.

Prodding with glass rods induced erratic swimming movements, characterized by tight spirals and returning to rest on the bottom (Belanger et al., 1986). This exposure was also associated with distortion of the lateral line regions and cellular histolysis resulting in eroding of the epidermis, extensive vacuolization of cells along the ventrum, tumorous swellings, and coelomic distentions. As the lateral line organs of fish are essential to orientation, and equilibrium maintenance, the observed adverse effects in the behavior of the exposed fish are associated with the lesions observed in the lateral line (Belanger et al., 1986).

Terrestrial Plants

To date, no studies have been located on the effects of asbestos in soil on terrestrial plants.

Soil Invertebrates

One study (Schreier and Timmenga, 1986) was located in which earthworms (*Lubricus rubellus*) were exposed to soils contaminated with asbestos under both field and laboratory conditions. However, no information was presented on the level of asbestos in the soils or the organisms or on the occurrence of effects in the worms. Several studies have documented an increase in levels of asbestos in soil invertebrate tissues collected on or near asbestos-contaminated sites. Near an asbestos-cement factory in India, asbestos fibers were detected in earthworms and snails, and higher concentrations were observed in worms compared to the soils (Musthapa et al. 2003). Two other studies (Glovinova et al., 1994 and Greig-Smith et al., 1992) also found substantial accumulation of asbestos and metals by earthworms surviving at a contaminated site. These data suggest that soil invertebrates such as worms are exposed to asbestos in soil and that they may tend to accumulate fibers. However, whether this results in adverse effects or not is unknown.

Mammals

There are numerous studies on the carcinogenic effects of both chrysotile and amphibole asbestos following inhalation exposure or intrapleural implantation. These studies are not considered here because carcinogenic effects on wildlife species are not typically of concern for ecological risk assessments unless they can be associated with adverse effects on growth, reproduction and survival.

To date, several studies have been identified that expose mammalian laboratory species to different forms of asbestos via inhalation or ingestion exposures. Most studies are with the chrysotile form of asbestos for ingestion exposures (gavage, drinking water or diet). The review of data for mammalian species focused on possible adverse effects to growth, reproduction or survival as these are the endpoints of potential concern for wildlife species.

For mammalian species exposed to amosite asbestos via inhalation exposures, no adverse effects on growth or survival were observed at exposures as high as 250 World Health Organization

(WHO) fibers (longer than 5 μ m) per cubic centimeter (cc). Histopathological effects on the lung, however, were observed at 25 WHO fibers/cc including bronchiolization, macrophages, neutrophils, mesothelial hyperplasia and hypertrophy, and many well-defined microgranulomas. The severity of effects increased with increasing dose (Hesterberg et al. 1997) (Attachment 1).

For mammalian species exposed to amosite asbestos via ingestion in drinking water, no effects on growth or survival were observed at exposures as high as 13,000 million fibers/liter (Smith et al., 1980). Exposures of amosite via gavage up to 100 mg/org did not result in any pathology changes to the small intestine (Meek, 1983) (Attachment 1).

For laboratory rats exposed to chrysotile asbestos via ingestion in dietary studies, no significant effects on growth or survival were observed at exposures as high as 360 mg/day over a 24 month period (Truhaut and Chouroulinkov 1989). A separate study, however, showed reduced growth in the first six weeks in juveniles over a lifetime exposures at 1% in the diet (Cunningham et al. 1977). Dietary exposures at 10% of the diet were associated with adverse colon histopathology (Donham et al. 1980). For exposures of chrysotile asbestos via ingestion in gavage studies, no significant effects on reproduction (pup survival, litter size, or growth of pups) were observed at 50 μ g/org (Haque et al., 2001) (Attachment 1).

The toxicity studies identified for asbestos exposures to mammals via either inhalation or ingestion are summarized in Attachment 1.

Birds

To date, there have not been any laboratory studies identified that expose avian species via inhalation, or ingestion to any form of asbestos. One study was identified that exposed chickens to asbestos via intrapleural injection (Peacock and Peacock, 1965) but this study was not reviewed as the exposure was not considered relevant for exposures to ecological receptors.

5.0 HISTOPATHOLOGY

5.1 Mammals

A large number of studies have been performed in animals to identify the effects of asbestos on the respiratory tract, and to a lesser degree on other organs (e.g. gastrointestinal tract). In animals, histological signs of tissue injury can be detected at the site of deposited fibers within a few days (ATSDR 2001). Some histological results are briefly summarized below.

Non-pulmonary Histopathology

Chronic studies of rats exposed orally to doses of 20-140 mg/kg/day chrysotile have described histological and biochemical alterations of cells of the gastrointestinal tract (Delahunty and

Hollander 1987, Jacobs et al. 1978a, 1978b). Lifetime studies performed by the National Toxicology Program (NTP) on rats and hamsters exposed to high doses (1% in the diet) of chrysotile, amosite, crocidolite, or tremolite did not detect any significant histological changes in any systemic tissues (NTP 1983, 1985, 1988, 1990a, 1990b, 1990c). However, in a chronic lifetime study on male rats exposed to high doses of chrysotile asbestos (1% in the diet), Cunningham et al. (1977) reported the presence of lesions in the parathyroid tissue, brain tissue, pituitary tissue, endothelial tissue, kidney tissue, and peritoneum tissue. No effects were reported in rats treated for only 6 weeks. This study also reported malignant tumors along the gastrointestinal tract of two of the rats in the test group, while no tumors were reported in the control group. Corpet et al. (1993) reported the induction of aberrant crypt foci in the colon, putative precursors of colon cancer, of female rats treated with a single dose of 30 mg/kg chrysotile asbestos, a single dose of 40 mg/kg crocidolite asbestos, or three doses of 33 mg/kg/day crocidolite asbestos by gavage. No effects were reported in mice that received either a single dose of 100 mg/kg chrysotile or three doses 50 mg/kg/day crocidolite.

Pulmonary Histopathology

A study by Reeves et al. (1974) reported histological changes in the form of fibrosis and sarcomas in the lung tissue of rats, rabbits, guinea pigs, gerbils, and mice exposed for two years to approximately 50 mg/m³ amosite asbestos via the inhalation route. Similar results were reported in animals exposed to 50 mg/m³ crocidolite or 50 mg/m³ chrysotile. Fibrosis has also been noted in rodents after exposure to 132 f/mL chrysotile for 5 hours (McGavran et al. 1989), exposure to 330 f/mL chrysotile for 15 weeks (Donaldson et al. 1988), and chronic exposure to 54-2,060 f/mL chrysotile and amphibole asbestos (Davis et al. 1980a, 1980b, 1985, 1986). Davis et al. (1978) reported histological changes in the lungs and alveoli of rats following 14-29 months of inhaling 10 mg/m³ asbestos dust. This study evaluated three different types of asbestos, crocidolite, chrysotile, and amosite. Lung tumors and lesions along the respiratory bronchioles, alveolar ducts, alveoli, and lung tissue were reported following exposure to all three types. However, the authors reported that granulomatous deposits around the terminal bronchioles appeared earlier in those rats exposed to chrysotile asbestos compared to those exposed to the amphibole asbestos. Peritoneal mesothelioma was only reported in the rats exposed to chrysotile asbestos. Mesotheliomas have been observed in rats and baboons following inhalation of asbestos (Davis and Jones 1988, Davis et al. 1985, Wagner et al. 1974, 1980, Webster et al. 1993).

5.2 Fish

Data on histopathological changes in fish exposed to asbestos are limited. A field study conducted along the Yukon River in Alaska (Yasutake 1982, 1983) and several laboratory investigations reporting histological changes occurring in fish exposed to chrysotile asbestos are briefly summarized below.

Field Observations

Naturally elevated levels of asbestos ranging as high as one billion amphibole fibers per liter water and 100 million chrysotile fibers per liter water have been reported in the Yukon River that runs through Canada and Alaska (Millette et al. 1983). Yasutake (1982, 1983) reported on the histopathology of gill, kidney, skin, muscle, heart, liver, and gut tissue of asbestos-exposed fishes collected during the summer from the Yukon River. The authors reported that the most consistent histopathological changes were observed in the gill lamellae, skin and kidney tubule epithelium. Changes in the gill consisted of lamella aneurysm as well as epithelial hypertrophy and/or hyperplasia, sloughing, degeneration and necrosis. Epidermal sloughing and a reduction in the number of mucus cells in the epidermis were noted among most fish. Amorphous foreign bodies were reported in the kidney tissues and there were noticeably more extensive intracytoplasmic ceroid-like material present in the epithelial cells of the renal tubules compared to "control" fish. Various stages of muscle fiber degeneration were observed in some of the fish, and most fish exhibited varying amounts of vacuolated liver cells. Yasutake et al. (1982, 1983) noted that the observed pathological changes were non-specific and could have been "caused by any combination of particulate matters, such as asbestos etc., trace and heavy metals and/or a number of miscellaneous chemicals".

Laboratory Observations

Studies by Belanger et al. (1986, 1990) investigated the effects of chrysotile asbestos on various life stages of Japanese Medaka (*Oryzias latipes*), coho salmon (*Oncorhynchus kisutch*), and green sunfish (*Lepomis cyanellus*). Epidermal thickening, epidermal lesions, and partial epidermal necrosis were observed among all species of fish tested. Histopathological examination of the lateral line organ in larval coho salmon treated with 3.0×10^{-6} f/l chrysotile asbestos revealed distorted lateral line regions characterized by severely eroded epidermis or the nerve resting in a constricted channel. Belanger et al. (1986) also observed abnormal swimming patterns and hypothesized a correlation with the destructive effects observed on lateral line histology. Two of 106 larval coho salmon exposed to chrysotile asbestos developed tumorous swellings in the gill region (Belanger et al. 1986). Two-month old Amazon mollies (*Poecilia formosa*) exposed to chrysotile asbestos in their aquarium water at concentrations of 0, 0.1, 1, 10 mg/L for 6 months developed lesions of the kidneys and gills (Woodhead et al. 1983). Three of twenty mollies exposed to 1 mg/L chrysotile asbestos showed small areas of vacuolation and necrosis of the sarcoplasm of the bulbus arteriosus in the heart tissue. No pathological changes were regularly seen in other organs that were examined including the liver and the muscles, and no effects were noted upon the skin.

6.0 REFERENCES

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Table 1. Analytical Methods for Analyzing Asbestos

METHOD	DESCRIPTION		MEDIA-SPECIFIC DETAILS			
			AIR	WATER	SOIL/SEDIMENT	TISSUE
Phase Contrast Microscopy (PCM)	Quantitative method used for estimating asbestos concentrations in air samples through an optical mechanism that visualizes differences in image contrast. This method cannot distinguish between asbestos types or differentiate asbestos from non-asbestos. Low magnification ~ 5 - 400X.	Counting Rules	AR ≥ 3:1, Length ≥ 5 µm, Thickness > detection limit (about 0.25 µm). Bundles counted as 1 structure unless individual fibers can be distinguished.			
		Quantification	Quantitative method. Limit of detection < 7 f/mm ² (usually 0.05 s/cc).			
		Reporting Units	Data are reported as structures per ml of air (s/cc).			
Polarized Light Microscopy (PLM)	Light is transmitted through a sample and then filtered with a polarizing lens in order to visualize its components. This method can distinguish between asbestos types and can differentiate asbestos and non-asbestos. Low magnification ~ 5 - 400X.	Counting Rules			AR ≥ 3:1, assign mineral type to 1 of 5 defined asbestos types.	
		Quantification			<u>Visual Area Estimation (VE)</u> : A semi-quantitative approach used to estimate the area fraction of the total material present in a field of view. <u>Point Counting (PC)</u> : Quantitative approach that involves counting the total number of particles (asbestos vs. non-asbestos) (generally 400 or 1,000) laying on superimposed points in the microscope field created by an ocular reticule (point array) or cross-hair. <u>Gravimetric (GRAV)</u> : Quantitative approach that estimates the mass percent of asbestos in the coarse fraction (>1/4")	
		Reporting Units			Area Fraction (AF) or Mass Fraction (MF) as a percentage. (Calibration standards required to estimate mass fraction).	
Transmission Electron Microscopy (TEM)	Quantitative method used for all media that can distinguish between different asbestos types based on energy-dispersive X-ray (EDS, EDX) which characterizes the elemental content and selected area electron diffraction (SAED) which characterizes the crystalline structure. Provides 2-dimensional look at asbestos morphology. High magnification ~ 500 - 20,000X.	Counting Rules	AR ≥ 3:1 Length ≥ 0.5 µm (ISO 10312 & AHERA)	AR ≥ 3:1 Length ≥ 10 µm (EPA 100.1 & 100.2)	AR ≥ 3:1 Length ≥ 0.5 µm (ISO 10312)	AR ≥ 3:1 Length ≥ 0.5 µm (ISO 10312)
		Quantification	Quantitative method. Sensitivity depends on volume of air collected, filter area, dilution factor and number of grid openings counted.	Quantitative method that determines numerical concentration and estimates mass concentration. Sensitivity depends on water quality (turbidity).	Qualitative, semi-quantitative - assigned as present or absent	Qualitative, Semi-Quantitative, Quantative - Depends on level of method validation
		Reporting Units	Data are reported as structures per ml of air (s/cc).	Data are reported as million fibers per liter of water (MFL).	Structures per gram of soil/sediment (s/g).	Structures per gram of tissue (s/g).
Scanning Electron Microscopy (SEM)	Quantitative method that can distinguish between different asbestos types based on energy-dispersive X-ray (EDS, EDX) which produces 3-dimensional images of asbestos morphology. High magnification ~ 50 - 10,000X.	Counting Rules			AR ≥ 3:1, may be < 3:1 for clearly fibrous particles. Classify into 3 asbestos types (LA, OA, C).	AR ≥ 3:1
		Quantification			Qualitative, semi-quantitative - assigned as present or absent	Qualitative, Semi-Quantitative, Quantative - Depends on level of method validation
		Reporting Units			Structures per gram of soil/sediment (s/g).	Structures per gram of tissue (s/g).



Scanning electron micrograph of asbestiform amphibole from a former vermiculite mining site near Libby, Montana. Source: U.S. Geological Survey and U.S. Environmental Protection Agency, Region 8, Denver, Colorado

Figure 1. SEM of Libby Amphibole

Organism Category	Exposure Route	Asbestos Type	Effect
Aquatic Invertebrates	Water	Primarily chrysotile, one study to date reports crocidolite	MOR, BEH, GRO, REP, PATH, ACC
Terrestrial Invertebrates	Diet	Chrysotile, amosite, crocidolite, tremolite	GEN
Aquatic Plants	Water	Chrysotile	ACC
Terrestrial Plants*	--	--	--
Fish	Water	Chrysotile	MOR, BEH, GRO, REP, PATH, ACC
Birds **	--	--	--
Mammals	Diet, gavage, inhalation	Chrysotile, amosite, chrysotile/crocidolite mixture	MOR, BEH, GRO, REP, PATH, ACC

*Papers on terrestrial plants have yet to be searched.

**To date no papers have been located that report on the oral or inhalation toxicity of asbestos in birds.

Summary of Toxicity Data to Date

Reference	Test Organism	Exposure Route	Asbestos Type	Summary of effects
Belanger et al. 1986	Asiatic clam	Water	Chrysotile	At levels of 10^4 f/l, decreased growth and decreased siphoning activity in adults exposed for 30 days, and reproductive toxicity in adults exposed for 14 days. Changes in gill ultrastructure of adult clams noted at levels of 10^8 f/l exposed for 30 days.
Belanger et al. 1986	Asiatic clam	Water	Chrysotile	No effect on juvenile mortality in clams exposed for 30 days. Decreased growth in juveniles exposed for 30 days to levels of 10^4 f/l. Seasonal differences in shell:tissue growth with lower values in the winter than the summer. Decreased siphoning activity in juveniles exposed for 30 days at levels of 10^2 f/l (summer) and 10^4 f/l (winter).
Stewart and Schurr 1980	Brine shrimp	Water	Chrysotile or Crocidolite	Minimum survival in 400 mg/l short fiber chrysotile. Short fiber chrysotile causes higher mortality than medium or long fiber chrysotile. Short fiber crocidolite causes same mortality as short fiber chrysotile, although there were issues with getting crocidolite into solution.
Osgood and Sterling 1991	Fly	Diet (sucrose-water)	Crocidolite, Chrysotile, Amosite, and Non-fibrous tremolite	In flies exposed for 3 days, chrysotile and amosite induce sex-chromosome aneuploidy in <i>Drosophila</i> oocytes. Chrysotile induced both chromosome gain and loss, while amosite only induced chromosome loss. Crocidolite and tremolite were ineffective in the assay test.
Belanger et al. 1986	Coho salmon and green sunfish	Water	Chrysotile	No effect on mortality at levels of 10^6 f/l. Following stress tests, coho larvae and juvenile sunfish exposed for 40-86 days demonstrated behavioral effects such as loss of rheotactic position and balance, corresponding to distortion of the lateral line region. Cellular histolysis of the ventral epidermal tissue.
Belanger et al. 1990	Japanese Medaka	Water	Chrysotile	Significant growth reduction in juvenile and larval fish exposed to 10^6 f/l, and 100% mortality at 10^8 f/l in 56 days of exposure. Significantly reduced spawning frequency in adult fish treated with 10^8 f/l. Exposed eggs did not exhibit adverse effects.
Cunningham et al. 1977	Wistar rats	Diet	Chrysotile	In rats fed a diet containing 1% chrysotile asbestos, grew significantly less than controls in the first six weeks of exposure. The difference in weight was maintained for several weeks and then the weight of the treated rats gradually approached that of controls.
Delahunty and Hollander 1987	Sprague-Dawley Rat	Drinking water	Chrysotile	Rats exposed to 0.5 g/l-day for 1.5 years showed no significant effect on growth or kidney function.
Donham et al. 1980	Fisher F344 rats	Diet	Chrysotile	Cellular function impacted in rats fed a diet containing 10% chrysotile asbestos for 32 months. Frequency of non-neoplastic lesions was not significantly different from controls.
Haque et al. 2001	ICR Mice	Gavage (saline vehicle)	Chrysotile	No significant reproductive effects seen in mice dosed with 50 ug chrysotile asbestos twice prior to pregnancy, and twice during gestation.
Hesterberg et al. 1997	Syrian Golden Hamsters	Aerosol (nose-only inhalation chambers)	Amosite	No significant effects on mortality or growth reported in hamsters treated with 250 WHO f/cc for 12 months. Lung weights were increased in hamsters treated with 125 WHO f/cc and 250 WHO f/cc. WHO fiber lung burdens showed time-dependent and dose-dependent increases. Severity of adverse lung effects increased with time and with dose.
Smith et al. 1980	Golden Syria hamsters	Drinking water	Amosite	No significant effect on mortality or growth in juvenile hamsters treated with up to 13000 millions of fiber/liter water per day over the lifetime of the animal.
Truhaut and Chouroulinkov 1989	Wistar Han SPF rats	Diet	Chrysotile only or Chrysotile (75%)/ Crocidolite (25%) mixture	No significant effect on mortality or growth in juvenile hamsters treated with up to 360 mg/day of either chrysotile only diet, or a mixture of chrysotile and crocidolite in the diet for 2 years.

*No studies on oral or inhalation toxicity in birds found to date.

Invertebrate Toxicity Data Extracted from Primary Literature

Reference	Record ID	Genus/Species	Common Name	Sex	Life Stage	Route of Exposure	Fiber Type	Analysis	Detection Limits/Sensitivity	Exposure	Exposure Units	Duration	Duration Units	Endpoint	Effect	Length Distributions	Width Distributions	NOEL	LOEL	Notes
Belanger et al. 1986	40520	<i>Corbicula fluminea</i>	Asiatic clam	NR	Adult (shell length 12.5-17 mm)	Water	Chrysotile	TEM	1.79E-04 - 6.91E-04 fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	96	hours	Behavior	Without food: decreased siphoning at 48 hours; by 72 hours at 1/5 control levels. With food: No significant difference from controls.	Not reported	Not reported	10^3 fl		
Belanger et al. 1986	40520	<i>Corbicula fluminea</i>	Asiatic clam	NR	Adult (shell length 12.5-17 mm)	Water	Chrysotile	TEM	1.79E-04 - 6.91E-04 fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	14	days	Reproduction	Significant increases in mortality of larvae and decreases in larvae released from adults exposed to 10^4 fl.	Not reported	Not reported		10^3 fl	
Belanger et al. 1986	40520	<i>Corbicula fluminea</i>	Asiatic clam	NR	Adult (shell length 12.5-17 mm)	Water	Chrysotile	TEM	1.79E-04 - 6.91E-04 fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days	Behavior	Decreased siphoning activity in all exposure groups.	Not reported	Not reported		10^3 fl	
Belanger et al. 1986	40520	<i>Corbicula fluminea</i>	Asiatic clam	NR	Adult (shell length 12.5-17 mm)	Water	Chrysotile	TEM	1.79E-04 - 6.91E-04 fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days	Growth	Decreased growth and decreased shell length in all exposure groups.	Not reported	Not reported		10^3 fl	
Belanger et al. 1986	40520	<i>Corbicula fluminea</i>	Asiatic clam	NR	Adult (shell length 12.5-17 mm)	Water	Chrysotile	TEM	1.79E-04 - 6.91E-04 fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days	Gill ultrastructural changes	Increased number of locules in each lamella ($p < 0.005$), and locules occupied significantly greater surface area.	Not reported	Not reported		10^3 fl	Only clams exposed to 10^3 fl/ml were examined for gill changes.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the summer)	Behavior	Decreased siphoning activity in all asbestos exposures relative to control except 10^3 fl in summer ($p < 0.05$).	Not reported	Not reported	10^3 fl	10^3 fl	Clams were collected and studied to compare seasonal differences (winter and summer). Controls mean siphoning activity of 70.8%, while exposed clams ranged from 53.1% (10^3 fl) to 68.7% (10^4 fl).
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the summer)	Growth	Significantly less shell and tissue growth at 10^4 fl and above.	Not reported	Not reported	10^3 fl	10^3 fl	Relative shell growth/tissue growth (mm/mg) greater in summer than winter.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the summer)	Mortality	No significant effect.	Not reported	Not reported	10^3 fl		2/120 (1.7%) died at highest exposure in summer. No mention of control survival.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the summer)	Gill ultrastructural changes	Increased size and surface area of locules in the gill at the highest exposure.	Not reported	Not reported	10^3 fl		Control clams possessed gill lamellae in which locules accounted for 14.7 \pm 3.1% of total surface area. Summer exposed clams accounted for 23.1 \pm 3.5%.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the summer)	Fiber Accumulation	Fibers accumulated in gill and viscera tissue in clams exposed to 10^4 fl. Fiber burdens - 10X greater in viscera (1100 fmg) than gill tissue (150 fmg).	Gills: 0.715 μ m - 0.832 μ m; Viscera: 1.977 μ m - 3.319 μ m; all significantly different from water.	Gills: 0.059 μ m - 0.099 μ m; Viscera: 0.292 μ m - 0.338 μ m; Viscera significantly different from water.			Control and 10^3 fl groups were below detection limits. Authors state that fiber accumulations in gill tissue are reflected in deteriorated gill tissue and greater tissue water content in asbestos exposed clams.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the winter)	Behavior	Decreased siphoning activity in all asbestos exposures relative to control in winter ($p < 0.05$).	Not reported	Not reported	10^3 fl		Clams were collected and studied to compare seasonal differences (winter and summer). Controls mean siphoning activity of 73.8%, while exposed clams ranged from 59.3% (10^3 fl) to 65.8% (10^4 fl).
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the winter)	Growth	Significantly less weight gain at 10^4 fl and above.	Not reported	Not reported	10^3 fl	10^3 fl	Clams exposed to 10^4 fl and above in winter had reduced shell and weight growth; however, only weight gain was significantly altered at 10^4 fl compared to controls.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the winter)	Mortality	No significant effect.	Not reported	Not reported	10^3 fl		3/60 (5%) died at highest exposure in winter. No mention of control survival.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the winter)	Gill ultrastructural changes	Increased size and surface area of locules in the gill at the highest exposure.	Not reported	Not reported	10^3 fl		Control clams possessed gill lamellae in which locules accounted for 16.7 \pm 4.2% of total surface area. Summer exposed clams accounted for 27.6 \pm 7.2%.
Belanger et al. 1986	17290	<i>Corbicula fluminea</i>	Asiatic clam	NR	Juvenile (5.2-8.6 mm shell length)	Water	Chrysotile	TEM	$< 10^4$ fl	$0, 10^1, 10^2, 10^3, 10^4$	fl	30	days (exposed in the winter)	Fiber Accumulation	Fibers accumulated in gill and viscera tissue in clams exposed to 10^4 fl. Fiber burdens - 10X greater in viscera (1100 fmg) than gill tissue (150 fmg).	Not reported for winter exposures.	Not reported for winter exposures.			Control and 10^3 fl groups were below detection limits.
Stewart and Schurr 1980	40420	<i>Artemia</i>	Brine shrimp	F	Larvae (3 days old)	Water	Chrysotile	SEM	Not reported	$1.2 \times 10^8, 2.4 \times 10^8, 4.8 \times 10^8, 9.6 \times 10^8$ (0, 200, 400, 800, 1600)	fl (mg/l)	24	hours	Mortality	Significant decrease in survival in all exposure groups compared to controls.	"Short fiber chrysotile" (Fiber length frequency plotted in Figure 4)	Not reported		200 mg/l	No significant difference between mortality among the exposure groups. Authors state that it is unclear if the cause of death is due to clogging of the filter feeding mechanism or ingestion of asbestos (applicable across all exposures).
Stewart and Schurr 1980	40420	<i>Artemia</i>	Brine shrimp	F	Larvae (3 days old)	Water	Chrysotile	SEM	Not reported	$6.1 \times 10^7, 1.2 \times 10^8, 2.4 \times 10^8, 4.8 \times 10^8$ (0, 200, 400, 800, 1600)	fl (mg/l)	24	hours	Mortality	Decrease in survival in all exposure groups compared to controls. Authors do not discuss significance.	"Medium fiber chrysotile" (Fiber length frequency plotted in Figure 4)	Not reported			In comparison to 3-day short chrysotile tests, no significant differences.
Stewart and Schurr 1980	40420	<i>Artemia</i>	Brine shrimp	F	Larvae (3 days old)	Water	Chrysotile	SEM	Not reported	$2.2 \times 10^7, 4.4 \times 10^7, 8.9 \times 10^7, 1.8 \times 10^8$ (0, 200, 400, 800, 1600)	fl (mg/l)	24	hours	Mortality	Decrease in survival in all exposure groups compared to controls. Authors do not discuss significance.	"Long fiber chrysotile" (Fiber length frequency plotted in Figure 4)	Not reported			In comparison to 3-day short chrysotile tests, only significant difference was for the 200 mg/l long fiber chrysotile concentration.
Stewart and Schurr 1980	40420	<i>Artemia</i>	Brine shrimp	F	Larvae (2 days old)	Water	Chrysotile	SEM	Not reported	$1.2 \times 10^8, 2.4 \times 10^8, 4.8 \times 10^8, 9.6 \times 10^8$ (0, 200, 400, 800, 1600)	fl (mg/l)	24	hours	Mortality	Significant decrease in survival in all exposure groups compared to controls.	"Short fiber chrysotile" (Fiber length frequency plotted in Figure 4)	Not reported		200 mg/l	Mean survival rates are higher than those for the 3-day old <i>Artemia</i> . A significant increase in survival is seen at all levels of asbestos concentrations except for the highest one compared to the 3-day old tests.
Stewart and Schurr 1980	40420	<i>Artemia</i>	Brine shrimp	F	Larvae (3 days old)	Water	Crocidolite	SEM (X-ray diffraction)	Not reported	$4.4 \times 10^7, 8.8 \times 10^7, 1.7 \times 10^8, 3.5 \times 10^8$ (0, 200, 400, 800, 1600)	fl (mg/l)	24	hours	Mortality	No significant effect compared to short fiber chrysotile.	"Short fiber amphibole" (Fiber length frequency plotted in Figure 4)	Not reported		1600 mg/l	Crocidolite allows a higher survival rate, although authors note that the crocidolite did not mix in the water as well as the chrysotile, as it tended to stay either at the top or bottom. In comparison to 3-day short chrysotile tests, significant differences in the 200 and 400 mg/l exposure groups only.
Osgood and Sterling 1991	30800	<i>Drosophila melanogaster</i>	Fly	F	Adult (3-4 days old)	Diet (sucrose-water)	Crocidolite	Not reported	Not reported	0, 5, 25	mg/ml	3	days	Chromosomal aneuploidy in offspring	No significant effect.	Not reported	Not reported	25 mg/ml		Insolubility in water may influence the lack of toxic response in this experiment. This study was not able to quantify how much asbestos was consumed or how much reached the oocytes.
Osgood and Sterling 1991	30800	<i>Drosophila melanogaster</i>	Fly	F	Adult (3-4 days old)	Diet (sucrose-water)	Chrysotile	Not reported	Not reported	0, 5, 25	mg/ml	3	days	Chromosomal aneuploidy in offspring	Significant response at both doses. Both chromosomal loss and gain. Approximately 5 times the control rate at the high dose. 2/6 aneuploidy in low dose from chromosome gain.	Not reported	Not reported		5 mg/ml	Authors suggest that the recovery of nearly equal numbers of chromosome gain and loss exceptions may indicate that it acts by disrupting the meiotic segregation apparatus rather than simply by inducing chromosome breakage.
Osgood and Sterling 1991	30800	<i>Drosophila melanogaster</i>	Fly	F	Adult (3-4 days old)	Diet (sucrose-water)	Amosite	Not reported	Not reported	0, 5, 25	mg/ml	3	days	Chromosomal aneuploidy in offspring	Significant effect at high dose with approximately 3 times the control rate. 8/9 attributable to chromosome loss.	Not reported	Not reported	5 mg/ml	25 mg/ml	
Osgood and Sterling 1991	30800	<i>Drosophila melanogaster</i>	Fly	F	Adult (3-4 days old)	Diet (sucrose-water)	Tremolite (non-fibrous)	Not reported	Not reported	0, 5, 25, 50	mg/ml	3	days	Chromosomal aneuploidy in offspring	No significant effect.	Not reported	Not reported	25 mg/ml		

Fish Toxicity Data Extracted from Primary Literature

Reference	Record ID	Genus/Species	Common Name	Sex	Lifestage	Route of Exposure	Fiber Type	Analysis	Fiber Identification/ Counting Rates	Exposure	Exposure Units	Duration	Duration Units	Endpoint	Effect	NOEL	LOEL	Notes
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Eggs-larvae	water	Chrysotile	TEM	Not reported	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13-21	days	Mortality	No significant effect	10^{10}	na	Two exposure systems - Petri dish and aquaria; (Percent Survival: 82.5-100% petri; 70-87.7% aquaria)
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Eggs-larvae	water	Chrysotile	TEM	Not reported	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13-21	days	Days to hatch	Longer hatching times compared to controls, although delays were 1 day or less (not biologically significant)	10^{10}	na	Patterns not strictly dose-dependent, eggs exposed to lowest dose in petri dishes took the longest to hatch, and at 10^6 finl the least time.
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Larvae-juvenile (<24 h old)	water	Chrysotile	TEM	Fiber ID and determinations were made by the Jaffe-Wick Washer technique of Anderson and Long (1980)	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13	weeks	Mortality	Nearly complete mortality (98%) at 10^7 fl by day 42. Gradual losses in 10^6 and 10^5 dose groups.	10^4	10^6	Less than 20% mortality in controls
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Larvae-juvenile (<24 h old)	water	Chrysotile	TEM	Fiber ID and determinations were made by the Jaffe-Wick Washer technique of Anderson and Long (1980)	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13	weeks	Growth	Significant reduction in total length starting by the second week at $10^7, 10^6$, and 10^5 fl.	10^4	10^6	By day 91, controls were ~30% larger than exposed fish. Trend for growth similar to mortality.
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Larvae-juvenile (<24 h old)	water	Chrysotile	TEM	Fiber ID and determinations were made by the Jaffe-Wick Washer technique of Anderson and Long (1980)	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13	weeks	Tissue Pathology	Thickening of epidermal tissue, irregular outer cell layer ("sculpting"). Partially necrotic tissue found to contain asbestos fragments.	10^4	10^6	
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Larvae-juvenile (<24 h old)	water	Chrysotile	TEM	Fiber ID and determinations were made by the Jaffe-Wick Washer technique of Anderson and Long (1980)	$0, 10^3, 10^4, 10^5, 10^6, 10^8$	fibers/l	13	weeks	Fiber uptake	At highest dose accumulation after only 1 month of 375.7 fmg. At dose of 10^6 fl after 3 months fish accumulated 486 fmg.			Authors state "asbestos uptake is implicated in reduced growth and increased mortality"
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Juvenile-adult larvae	water	Chrysotile	TEM	Not reported	$0, 10^3, 10^4$	fibers/l	4	months	Reproduction	No significant effect month-by-month analysis; Successful spawning and viability of eggs reduced based on a cumulative analysis.	10^4	10^6	Fish were exposed for 4 months followed by a one month recovery period. Decreased spawning frequency and egg viability, although these effects were not significantly different from controls.
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Juvenile-adult larvae	water	Chrysotile	TEM	Not reported	$0, 10^3, 10^4$	fibers/l	4	months	Growth	No significant effect	10^4		Differences compared to juvenile larvae could be due to exposure system (76-L aquaria vs 4-L aquaria) and initial age of exposure.
Belanger et al. 1990	29770	<i>Oryzias latipes</i>	Japanese Medaka	MF	Juvenile-adult larvae	water	Chrysotile	TEM	Not reported	$0, 10^3, 10^4$	fibers/l	4	months	Post-exposure egg survival, hatch	No significant effect	10^4		Suggests transfer from adults to offspring did not occur.
Woodhead et al. 1983	27070	<i>Poecilia formosa</i>	Amazon molly	F	2 months old	water	Chrysotile	NR	Not reported	$0, 0.01, 0.1, 1, 10$	mg/L	6	months	Kidney damage	Varying degrees of selective necrosis of the hemopoietic tissue, characterized by the development of "holes" or spaces. Greater in mollies exposed to fine suspensions possibly from accumulation across the intestinal mucosa.	10		Differences between fish exposed to a coarse suspension of asbestos (0.1, 1, 10 mg/L) and a fine suspension of asbestos (0.01, 0.1, 1 mg/L), due to concentration differences. Unable to assign quantitative values for extent and degree of tissue damage, except in mollies exposed to 10 mg/L of the coarse suspension. Widespread fusion of the gill lamellae and numerous aneurysms in these fish.
Woodhead et al. 1983	27070	<i>Poecilia formosa</i>	Amazon molly	F	2 months old	water	Chrysotile	NR	Not reported	$0, 0.01, 0.1, 1, 10$	mg/L	6	months	Gill lesions	Aneurysms, proliferation of the gill epithelium, hypertrophy and hyperplasia of cells at the base of the secondary lamellae, fusion of lamellae.	1	10	
Woodhead et al. 1983	27070	<i>Poecilia formosa</i>	Amazon molly	F	2 months old	water	Chrysotile	NR	Not reported	$0, 0.01, 0.1, 1, 10$	mg/L	6	months	Heart lesions	No significant effect	10		
Belanger et al. 1986	16930	<i>Oncorhynchus kisutch</i>	Coho salmon	MF	Larvae	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	40-86	days	Mortality	No significant effect	$3.00E+06$		Based on levels of chrysotile exposures approximating those reported in the Great Lakes basin ($1e+06$ fl).
Belanger et al. 1986	16930	<i>Oncorhynchus kisutch</i>	Coho salmon	MF	Larvae	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	40-86	days	Behavioral effects	Loss of rheotactic position and balance in the high dose group.	$1.50E+06$	$3.00E+06$	Fish found laying on their sides in the bottom of the tank by day 13, by day 20 nearly all fish were displaying this behavior. Prodding with glass rods induced erratic swimming movements, characterized by tight spirals and returning to rest on the bottom.
Belanger et al. 1986	16930	<i>Oncorhynchus kisutch</i>	Coho salmon	MF	Larvae	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	40-86	days	Histopathology	Distortion of the lateral line regions and cellular histology resulting in eroding of the epidermis. Extensive vacuolization of cells along the ventrum. Two fish developed tumorous swellings, and three additional fish developed osteoclastic distentions.	$1.50E+06$	$3.00E+06$	Evidence of the presence of asbestos in larvae using TEM. Lateral line organs are essential in orientational ability, maintenance of equilibrium, and acts as a major recipient of environmental information in fish. All controls displayed normal development and configuration of the lateral line.
Belanger et al. 1986	16930	<i>Oncorhynchus kisutch</i>	Coho salmon	MF	Larvae	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	40-86	days	Stress test (exposed to TMS)	Ataxic and loss of equilibrium faster than controls.		$1.50E+06$	Study measured susceptibility to trichloroethane/sulfate (TMS) anesthesia in asbestos treated fish.
Belanger et al. 1986	16930	<i>Oncorhynchus kisutch</i>	Coho salmon	MF	Larvae	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	40-86	days	Growth	No significant effect	$3.00E+06$		Average total lengths of control and treated fish were not significantly different. Authors declare the results of the anesthetic response attributable to exposure or lack of exposure to asbestos, and not to differences in body size.
Belanger et al. 1986	16930	<i>Lepomis cyanellus</i>	Green sunfish	MF	Juvenile	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	52-67	days	Mortality	No significant effect	$3.00E+06$		
Belanger et al. 1986	16930	<i>Lepomis cyanellus</i>	Green sunfish	MF	Juvenile	water	Chrysotile	TEM	Fiber morphology outlined by Miller (1978)	$0, 1.50E+06, 3.00E+06$	fibers/l	52-67	days	Histology	Loss of scales and skin surface tissues	$1.50E+06$	$3.00E+06$	

Mammalian Toxicity Data Extracted from Primary Literature

Reference	Record ID	Common Name	Sex	Lifespan	Route of Exposure	Fiber Type	Analysis	Counting Rate	Exposure	Exposure Unit	Duration	Duration Unit	Length Distributions	Width Distributions	Endpoint	Effect	Notes
Haque et al. 2001	15510	ICR Mice	F	Adult - pregnant	Gavage (tealite vehicle)	Chrysotile	SEM + EDXA	Not reported	0, 50	µg	Single dose on days 2 and	Not reported			Litter size	No effect	10 pups/litter treated; 11 pups/litter control
Haque et al. 2001	15510	ICR Mice	F	Adult - pregnant	Gavage (tealite vehicle)	Chrysotile	SEM + EDXA	Not reported	0, 50	µg	Single dose on days 2 and	Not reported			Growth of pups	No significant effect	Treated pups demonstrated decreased weight gain compared to controls but the difference was not significant.
Haque et al. 2001	15510	ICR Mice	F	Adult - pregnant	Gavage (tealite vehicle)	Chrysotile	SEM + EDXA	Not reported	0, 50	µg	Single dose on days 2 and	Not reported			Pup mortality	No significant effect	Postnatal fetal mortality higher in treated group; 5/61 pups (8.2%) died versus 3/66 (4.5%) pups from the control group.
Haque et al. 2001	15510	ICR Mice	F	Adult - pregnant	Gavage (tealite vehicle)	Chrysotile	SEM + EDXA	Not reported	0, 50	µg	Single dose on days 2 and	Not reported			Transplacental fiber uptake by pups	Detectable fibers in lungs and livers of pups from exposed adult mice.	Body burden
Hilding et al. 1981	10466	Sprague-Dawley Rat	NR	Weanling	Diet (Cottage cheese)	Chrysotile and Amosite	Electron Microscopy (USEPA)	Not reported	0, 20	mg/rat-day	870	days	Not reported	Not reported	Tumor incidence	Seven rats developed malignant tumors (carcinoma, fibrosarcoma, lymphoma, and one mesothelioma). 15 developed benign breast fibroadenomas. Cancer frequency is not statistically significant at the 5% level (0.225 < P < 0.5) by X2. (N = 30)	No report of gastrointestinal cancer. 5 mg/g cheese per day (Low Dose Chrysotile first 7 months, amosite for remainder). Departure from null hypothesis of no difference are not statistically significant at the 5% level (0.225 < P < 0.5) by X2. (N=20)
Hilding et al. 1981	10466	Sprague-Dawley Rat	NR	Weanling	Diet (Cottage cheese)	Chrysotile and Amosite	Electron Microscopy (USEPA)	Not reported	0, 300	mg/rat-day	750	days	Not reported	Not reported	Tumor incidence	One rat developed leukemia, ten rats developed breast fibroadenomas, and one rat developed leiomyoma.	No report of gastrointestinal cancer. 50 mg/g cheese per day (High Dose - amosite only). Departure from null hypothesis of no difference are not statistically significant at the 5% level (0.225 < P < 0.5) by X2. (N=20)
Dehnbury and Hollander 1987	18390	Sprague-Dawley Rat	Male	NR	Drinking water	Chrysotile	Not reported	Not reported	0, 0.5	µl - day	1.5	years	Not reported	Not reported	Growth	No significant effect	Initial weight: 150 - 200 g Final weight: Controls - 368 g, Treated - 353 g
Dehnbury and Hollander 1987	18390	Sprague-Dawley Rat	Male	NR	Drinking water	Chrysotile	Not reported	Not reported	0, 0.5	µl - day	1.5	years	Not reported	Not reported	Intestinal permeability	Decreased absorption of some non-metabolizable sugars (lactulose and mannitol).	Suggested by authors that may indicate that asbestos blocked the usual route for penetration of these compounds. Absorption of thiamine- no significant effect.
Dehnbury and Hollander 1987	18390	Sprague-Dawley Rat	Male	NR	Drinking water	Chrysotile	Not reported	Not reported	0, 0.5	µl - day	1.5	years	Not reported	Not reported	Kidney Function	No significant effect	No difference in the clearance of creatine suggests that the asbestos treatment did not cause impairment of kidney function.
Donschen et al. 1984	8610	Fisher F344 rats and Holtzman rats	Male	Weanling (Fisher) and adult (Holtzman)	Diet	Chrysotile	Not reported	Not reported	0, 10	percent weight/weight basis	350	days	Not reported	Not reported	Tumor incidence (Colon)	Two rats developed adenocarcinomas, one rat developed a sarcoma. Not a significant difference in tumor rates with the control group.	No tumors seen in the control group, but the authors state that the combined fiber groups (asbestos and cellulose) were not significantly different from the standard diet group. Study evaluates effect of asbestos fed rats treated with X-irradiation. Adenocarcinomas developed in localized areas of x-ray treatment. Other lesions of the colon documented. Ten rats demonstrated no lesions.
Meek 1983	40390	Wistar rats	NR	NR	Gavage	Amosite	Light microscopy (no further detail)	Not reported	100	mg/rat-day	5	days	Not reported	Not reported	Pathology	No significant effect	No evidence of macrophage response or other pathological changes in the small intestine. No mention of controls.
Meek 1983	40390	Wistar rats	NR	NR	Gavage (corn oil)	Amosite	PLM	Not reported	0, 100 (+25)	mg/rat-day	2	days	Not reported	Not reported	Transmigration in regions of ulceration of the GI tract	No intracellular fibers observed in areas of the GI tract with visible ulcerations.	Rats received 100 mg amosite daily by gavage for 2 days, on the third day, 10 mg/kg indomethacin was administered to induce ulcers. The asbestos treated rats received a further 25 mg dose of amosite on the same day and daily thereafter until they were killed. Authors suggest the gut wall of rats may present an effective barrier to the penetration of asbestos even under conditions of epithelial loss. Limitations in exposure duration, no histological examination of macrophages.
Smith et al. 1980	11180	Golden Syria hamsters	MF	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	TEM/SEM	Not reported	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime		Measurements by SEM at x600 as reported in Record ID #10940 (Smith et al. 1980) show the percentage of fibers longer than 10 µm to be 14%, and the percentage longer than 20 µm to be 25%.	Not reported	Mortality	No significant effect	Median survivorship of males was 448 days, for females was 393 days. For males and separately for females, the asbestos group, median survival times at 95% CI overlapped controls.
Smith et al. 1980	11180	Golden Syria hamsters	MF	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	TEM/SEM	Not reported	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime		Measurements by SEM at x600 as reported in Record ID #10940 (Smith et al. 1980) show the percentage of fibers longer than 10 µm to be 14%, and the percentage longer than 20 µm to be 25%.	Not reported	Growth	No significant effect	Differences in body weight are inconclusive, since they are neither dose related nor treatment-related.
Smith et al. 1980	11180	Golden Syria hamsters	MF	Juveniles (2 months old)	Drinking water (continuous flow of air bubbles)	Amosite	TEM/SEM	Not reported	0, 130, 1300, 13000	millions of fibers/liter - day	Lifetime		Measurements by SEM at x600 as reported in Record ID #10940 (Smith et al. 1980) show the percentage of fibers longer than 10 µm to be 14%, and the percentage longer than 20 µm to be 25%.	Not reported	Tumor incidence	Not a significant difference in tumor rates from controls.	A peritoneal mesothelioma, pulmonary carcinoma and two early squamous cell carcinomas of the forestomach were found in exposed hamsters. The tumors could not be specifically attributed to amosite.
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Survival	No significant effect	
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Growth	No significant effect	
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Tumor incidence	No significant effect	By the end of the experiment there were high numbers of rats with tumors, both controls and exposed rats.
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%) / Crocidolite (25%) mixture	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Survival	No significant effect	N = 68-70 per exposure group (including control group).
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%) / Crocidolite (25%) mixture	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Growth	No significant effect	
Trubost and Chouvalnikov 1989	5930	Wistar Han SPF rats	MF	Juveniles (5-6 weeks old)	Diet (palm oil)	Chrysotile (75%) / Crocidolite (25%) mixture	NR	Not reported	0, 10, 60, 360	mg/day	24	months	Not reported	Not reported	Tumor incidence	No significant effect	
Hesterberg et al. 1997	2630	Syrian Golden Hamsters	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	SEM	AR ±3.1, W < 3 µm, L > 3 µm	0, 25, 125, 250	WHO fcc	12	months	Low = 13.7 ± 17.0 µm; Medium = 12.5 ± 16.0 µm; High = 14.0 ± 17.1 µm (arithmetic means through 12 months in aerosol).	Low = 0.60 ± 0.24 µm; Medium = 0.58 ± 0.24 µm; High = 0.59 ± 0.24 µm (arithmetic means through 12 months in aerosol).	Mortality	No significant effect	Mortality study was compromised by an infectious disease diagnosed as wet tail (increased mortality during weeks 17 to 26). Treatment of hamsters with tetracycline. After the 26-week time point, mortality rates returned to levels similar to previous hamster studies.
Hesterberg et al. 1997	2630	Syrian Golden Hamsters	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	SEM	AR ±3.1, W < 3 µm, L > 3 µm	0, 25, 125, 250	WHO fcc	12	months	Low = 13.7 ± 17.0 µm; Medium = 12.5 ± 16.0 µm; High = 14.0 ± 17.1 µm (arithmetic means through 12 months in aerosol).	Low = 0.60 ± 0.24 µm; Medium = 0.58 ± 0.24 µm; High = 0.59 ± 0.24 µm (arithmetic means through 12 months in aerosol).	Growth	No significant effect	Average body weights did not differ from sham-exposed controls.
Hesterberg et al. 1997	2630	Syrian Golden Hamsters	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	SEM	AR ±3.1, W < 3 µm, L > 3 µm	0, 25, 125, 250	WHO fcc	12	months	Low = 13.7 ± 17.0 µm; Medium = 12.5 ± 16.0 µm; High = 14.0 ± 17.1 µm (arithmetic means through 12 months in aerosol).	Low = 0.60 ± 0.24 µm; Medium = 0.58 ± 0.24 µm; High = 0.59 ± 0.24 µm (arithmetic means through 12 months in aerosol).	Lung Weights	Significantly increased compared to controls for the mid- and high dose groups.	After 13 and 52 weeks of inhalation, mid and high dose groups demonstrated significantly elevated lung weights compared to the air controls.
Hesterberg et al. 1997	2630	Syrian Golden Hamsters	M	13-15 weeks old	Aerosol (nose-only inhalation chambers)	Amosite (low)	SEM	AR ±3.1, W < 3 µm, L > 3 µm	0, 25, 125, 250	WHO fcc	12	months	Low = 13.7 ± 17.0 µm; Medium = 12.5 ± 16.0 µm; High = 14.0 ± 17.1 µm (arithmetic means through 12 months in aerosol).	Low = 0.60 ± 0.24 µm; Medium = 0.58 ± 0.24 µm; High = 0.59 ± 0.24 µm (arithmetic means through 12 months in aerosol).	Histopathology	Bronchiolization, macrophage, neutrophil, mesothelial hyperplasia and hypertrophy, and many well-defined microgranulomas (some containing fibers) at the low dose. Severity increased at the mid- and high dose groups. High dose group also demonstrated hepatization.	WHO fiber lung burden showed time-dependent and dose-dependent increases. Severity of adverse lung effects increased with time and with dose.
Donschen et al. 1980	11530	Fisher F344 rats	MF	Weanling	Diet	Chrysotile	NR	NR	0, 10 % of diet	percentage of diet	32	months	Not reported	Not reported	Colon histopathology	Four tumors in the exposed rats, two tumors in the control rats. One mesothelioma in exposed rats. Non-neoplastic lesions were reported but frequency was not significantly different from control.	Actualistic analysis demonstrated that asbestos-fed rats were eventually at a greater risk for lesions (17.9%) compared to controls (8.2%).
Donschen et al. 1980	11530	Fisher F344 rats	MF	Weanling	Diet	Chrysotile	NR	NR	0, 10 % of diet	percentage of diet	32	months	Not reported	Not reported	Cellular function	Significantly decreased cAMP levels compared to the controls.	Authors suggest this indicates a serious, cell-regulator defect related to asbestos ingestion.
Cunningham et al. 1977	12450	Wistar rats	M	Weanling	Diet (corn oil)	Chrysotile	Electron Microscopy (not specified)	NR	0, 1 % of diet	percentage of diet	Lifetime		0.3-10 µm 49% 3.15-8 µm 9% 5.1-10 µm 10% 10.1-50 µm 10%	Not reported	Growth	Decreased growth rate in the first 6 weeks of exposure. Differences in weight from controls was maintained for several weeks and then the weight of the treated rats gradually approached that of the controls.	Two experiments: 1 used 10 rats/group, 1 used 20 rats/group.

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